THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science,

HALIFAX, NOVA SCOTIA.

VOLUME IX,

(BEING VOLUME II OF THE SECOND SERIES.)

1894-98.

WITH TWO PORTRAITS AND TEN PLATES.

HALIFAX:
PRINTED FOR THE INSTITUTE BY THE NOVA SCOTIA PRINTING COMPANY.
1898.

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PROCEEDINGS.

TRANSACTIONS.

ERRATA.

P. 130.—The numbers in the third column of the first table should be multiplied by the ratio of the number of gramme-molecules of Sodium Chloride to the number of gramme-molecules of Potassium Chloride, in the corresponding constituent solutions.

P. 132.—The numbers in the fourth column of the table should be multiplied by the ratio of the number of gramme-molecules of Sodium Chloride to the number of gramme-molecules of Hydrochloric Acid in the constituent solutions.

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SESSION OF 1894-95.

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(Being Volume II of the Second Series).

PART 1.

WITH SIX PLATES.

The First Series consisted of the Seven Volumes of the Proceedings and Transactions of the Nova Scotian Institute of Natural Science.

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CONTENTS.

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1894-5.

Annual Business Meeting.

Provincial Museum, Halifax, 12th November, 1894.

Prof. George Lawson, LL. D., President, in the chair.

The minutes of the last annual meeting were read and approved.

The President addressed the Institute as follows:—

Gentlemen,— We have assembled this evening as Members of the Nova Scotian Institute of Science, for the performance of two distinct duties,—first, to close the session of 1893-94, which we now speak of as past; and secondly, to enter upon the operations of another year and lay plans for the future. We are thus required, Janus-like, to put on two faces, one looking backward, the other forward. The annual address must be to a large extent a looking backward, for it is expected we shall give some account of our stewardship. It is my place as president to deliver the address on this occasion, because a year ago you thought fit to appoint me to fill your most honorable office. I was conscious that you might well have made a better choice, for I felt that the president of a scientific body like this should be prepared to give time and energy for more arduous labor than that of sitting in a chair at the monthly meetings. I was not ignorant of the fact that the most active workers are apt to entertain an abnegative spirit in regard to such things, to shirk prominence and seek gratification in the quiet pursuit of knowledge rather than the attainment of personal distinction. While this

spirit was to be respected, it did not afford a sufficient reason for my acceding to your request; but, on the other hand, I knew that the compliment which you wished to pay me after thirty years' membership of the Institute was sincere, and was actuated by the kindliest feelings. When, moreover, I was assured of substantial help from the resident vice-president and secretaries, it seemed that no other course was left me but to accept the position, to thank you all for the honor conferred upon me, and proceed to do what I could in discharge of the duties so undertaken.

And now that my term of office is completed, I ask your attention to a brief review of the operations of the year. This will enable us the better to realize our position in the present, and to forecast the work that remains for the future. So fortified, we may make a fresh start.

It is pleasing to be able to record that this year our membership has not been reduced either by death or resignation. Our list has been increased by the admission of seven ordinary and two corresponding members.

During the session, seven ordinary monthly meetings for the reading of scientific papers were held. At these meetings twenty papers were read; their subjects presented considerable variety. The session commenced, in accordance with our laws, with the annual meeting of members of 8th November, when Dr. Martin Murphy, the retiring President, read an address, in which he reviewed the work of the byegone year. On the same evening an ordinary public meeting was constituted. The first paper read was by Prof. MacGregor, of Dalhousie College, on the isothermal and adiabatic expansion of gases; its object was to show how certain important laws of the expansion of gases extensively employed in the study of heat engines, and usually demonstrated by the aid of the calculus, may be demonstrated by the use of elementary mathematical methods. The demonstration of these laws was thus brought within the comprehension of engineers who had not had the advantage of an extensive mathematical training.

At the December meeting, Dr. Somers called attention to the native forms of juniper, giving details of his observation of the variations in habit of these plants, and exhibiting living specimens showing more particularly the upright arborescent or tree-forms of Juniperus communis, a species which, both in Europe and America, commonly appears on bare hills and sand-dunes as a depressed bush without any

erect main stem. He also exhibited a stuffed specimen of Lanius borealis, and read notes on its butcher-bird habits, distribution, and local occurrence. Both of these subjects elicited information from members of observations they had made. The discussion that ensued in regard to the juniper-forms led to expression of the view that depressed and bush forms of Coniferæ are to be regarded in general, not as incipient trees in process of development or evolution, but rather as degenerate or dwarfed forms of species that now exist, or have formerly existed, normally as trees. We do not now have the proper forest-tree-form of Juniperus communis anywhere, but our native yew bush, Taxus Canadensis, while it occurs nowhere on *this* continent as a tree, is believed by many botanists to be conspecific with the English yew, the trunk of which attains great size as well as antiquity; it is the tree that furnished wood for bows to the English bowmen. Mr. Guildford R. Marshall, Principal of Richmond School, gave an account of the observation of earthworms on roofs, etc., as if they had fallen in a shower; the facts narrated suggested several possible explanations of the phenomenon, in connection with which details of the habits of these familiar but despised creatures were brought forward by members. At the same meeting, the President offered remarks on some features of the Kentucky Flora, pointing out the prominent differences in the vegetation of the Kentucky plains or low-lands from that of Nova Scotia, while the hill or mountain plants were, in certain cases, identical with our species, or presented equivalent forms. These remarks were founded on, and illustrated by, specimens collected during the season by Mr. Kearney, of the Botanical Department of Columbia College, New York where much good botanical work is being done.

At the January meeting (1894), Dr. Gilpin, Deputy Commissioner of Mines, gave a geological description of the Nictaux iron-ore-field, which has of late years acquired increased economic importance. The reading of this paper led to an interesting discussion on the general geological features of the district, which was familiar to Dr. A. P. Reid and other members present. Mr. Doane, our City Engineer, gave an account of the operation of the "Kennedy Scraper," so-called, and an explanation of the cause of a recent failure in its working when introduced into the city water pipes. The interesting history of this invention for automatically freeing water-pipes from rust-incrustation was detailed, the apparatus shown, its mode of working described, and its use in our city water works fully explained.

The February meeting was occupied with botanical subjects. Notes were given on the botanical and commercial history of Nova Scotian foxberries, an export trade in which has been developed to a surprising extent within the last few years, especially in Guysborough County. Mr. G. H. Cox, B. A., communicated a list of plants collected in and around the Town of Shelburne, on the Atlantic Coast of our Province, in the years from 1890 to 1893. The Institute had previously given space in its Transactions (vol. VI, pp. 209-300, and pp. 283-285) to two similar lists of native plants of Truro, in Colchester County, by Dr. George G. Campbell, which are supplemented this year by a list of additional species collected in that locality by Percy J. Smith. Such lists as these, when prepared with care, form valuable material for the preparation of local floras, as well as for Provincial or more general works, and the opportunity should not be lost to call attention to the substantial service that may be rendered to botanical science by the preparation of such lists for localities throughout the Province by those who have opportunities, by residence or otherwise, for local observation and collection.

The March meeting was taken up with astronomical and chemical subjects. Mr. Cameron, Principal of Yarmouth Academy, whose papers on astronomical observation, published in the periodical press at different times, have so greatly interested the general public, gave us his notes of observations on Venus. These notes may be regarded as a sequel to his previous papers on that planet, of which he has for some years made a special study, with regard more particularly to her visibility from the earth under the changing conditions of elongation from the sun, brilliancy, position, and state of our atmosphere. It seems desirable, therefore, to advert briefly to the general results reached by the author in each of his two previous papers.

In the first volume of the second series of our Transactions, Session 1892-93 (pp. 148-159), Mr. Cameron dealt with the enquiry: On how many (astronomical) days in the year may Venus be seen with the naked eye? The answer to this question involved a discussion of the motion and changes of the planet and of the geometrical conditions upon which her brilliancy depends. By constant watchfulness he succeeded in recording a valuable series of observations at Yarmouth, while notes of others made at Marseilles were obtained from M. Bruguiere, who had been engaged on the very same work for several years before. During

1890, when Venus began her season as evening star with the superior conjunction of February 13th, and ended with the inferior conjunction of December 4th (a period of 290 days), Mr. Cameron saw her with the naked eye as early as March 16th, and Mr. Bruguiere as late as November 29th, so that she was visible to the naked eye that season on 259 days out of the total 290. In his second paper (Trans. Inst., ser. 2, vol. I, pp, 345-358), our author dealt with the visibility of the planet in *daylight* to the naked eye and with aid of the opera-glass, and effectually dispelled the common notion that Venus could be seen with the naked eye in daylight on very rare occasions only. From the long course of patient, I might say persistent, observations made, Mr. Cameron was enabled to determine that on the average, out of every 100 days there are 84 on which any star-gazer with a fairly good eye can see Venus in daylight, if the weather permits and if he knows where to look for her. The paper of the past session brings the bright planet before us in another role, its object being to detail observations of her performance of the two characters of *evening* and *morning* star "at the same time," and to explain the conditions which bring about this phenomenon. The paper will be found *in extenso* in the forthcoming part of the Transactions now passing through the press. One feature of these papers ought not to be omitted; they consist not of mere observations and results (although it will be seen that these are of great interest), but give details explaining clearly the facts necessary to be known by those who, without having the advantage of previous training in systematic observation, may wish to observe for themselves the phenomena so well described; these papers will thus serve as a guide to young observers, and may help to correct the fault which their author finds with the general public, who, nowadays, he thinks, are not much given to looking heavenward either by night or by day. We wait with expectancy for the next secret which Mr. Cameron is going to wrest from the fair star of his affection.

At the same meeting, Mr. F. J. A. McKittrick, B. Sc., communicated a paper on the measurement of the resistance of electrolytes; it consisted chiefly of a report of research work done in the Physical Laboratory of Dalhousie College under Prof. MacGregor, and may be regarded as an earnest of still more important work that is expected from Mr. McKittrick in the future, for he was this year nominated by the University Senate, and accepted by Her Majesty's Commissioners of

the London Exhibition of 1851 as recipient of one of their Science Scholarships. This scholarship, of the annual value of one hundred and fifty pounds sterling, is tenable for two years on the condition that, during his tenure, the holder shall devote himself wholly to study and research, more especially in some branch of science, such as physics mechanics or chemistry, the extension of which is especially important to our national industries. The Senate's nomination to the Royal Commissioners was accompanied by a copy of Mr. McKittrick's paper from the Institute's Transactions to show the author's capacity for research work.

Mr. D. M. Bliss, electrician, Amherst, in a paper titled, "The coming development of artificial illumination," set forth a number of interesting facts and problems that are now engaging the attention of electrical engineers, and that are not only of scientific interest, but also prospectively of economic importance to civilized communities.

Mr. John Forbes, whose mechanical inventions in connection with iron manufactures have brought fame to our city, presented us with a review of some modern methods in manufacturing, with suggested analogies from a study of the evolution and nature of some of the processes employed. The reading of this paper led to an interesting discussion on the processes of manufacture of the different kinds and qualities of iron and steel, the observations of the speakers being well illustrated by a series of samples exhibited by Mr. Forbes, which showed the several progressive steps in the processes of manufacture.

Our April meeting was held in the Church of England Institute building; the attendance was unusually large, both of ladies and gentlemen, notwithstanding the disagreeable weather. The evening was entirely devoted to a paper by Dr. D. A. Campbell, titled, "General considerations concerning Bacteria, with notes on the bacteriological analysis of water." Dr. Campbell had studied Bacteriology at Johns Hopkins University, where unusually ample facilities are offered, and he has continued the investigation since his return to Halifax. In this paper he gave a clear exposition of the most important results of bacteriological enquiry up to the present time. He described the principal forms of bacteria, with respect to their characteristic features in form and size, the changes which they undergo, the parts they play in the economy of nature, as in putrefactive processes, in converting organic substances

into suitable compounds for plant food, and in their relation to such diseases as anthrax in the lower animals, and diphtheria and cholera in the human race. The author described the general methods of bacteriological work; the modifying modes of culture by which vaccines are produced, and showed the several forms of apparatus and appliances used. The whole subject was admirably illustrated by preparations and live cultures shown under excellent microscopes. The water supplied to the City of Halifax had been examined, and was found to be remarkably free from deleterious bacteria ; the author, however, offered suggestions as to keeping the lakes clear of decaying vegetable matter that might at any time menace the health of the city. The animated discussion that followed was a feature of the meeting. Dr. A. H. Mackay, who had also studied the subject, showed by calculation the prodigious rate at which bacteria multiply, and enforced upon the audience the object lesson of necessity for scrupulous cleanliness in the kitchen which the fleeting life-histories of the bacteria taught us. Dr. Somers expressed his belief that the investigation of bacterial phenomena was of scientific interest, but he could not admit that the germ theory of disease had been established. Dr. A. P. Reid, on the other hand, regarded bacteriology as of vital importance to the medical profession, and to the people, and congratulated the Institute on being the means of presenting to the community an exposition and illustration of this subject that every one could appreciate ; to-night, he said, for the first time in the history of medical science in Halifax, the living and moving bacillus of cholera had been shown.

The May meeting, being the last of the session, was overcrowded with papers ; eight were brought forward, several having lain over from previous meetings. Some had to be read by title only. The first was a notice of a new test for Antipyrine, by the President. Antipyrine is the therapeutical name and that commonly used, for the chemical compound properly called oxy-phenyl-dimethyl-pyrazole, or phenyl-dimethyl-pyrazolon ; it belongs to the great class of aromatic compounds, of which Benzene CH_6 is the type ; but it differs from the benzene derivatives in containing a pentagonal in place of a hexagonal nucleus, The chemical constitution of the compound was explained by means of diagrams of the graphic formulæ of related compounds, and the several known tests were shown. The special test referred to for detecting, or confirming the detection, of this compound, is the re-action obtained by prolonged boil-

ing with strong nitric acid, a brilliant solution somewhat like that of roseine, but with a purplish tinge, being produced.

Dr. MacKay, the Superintendent of Education, presented a valuable summary of observations for the season of 1893, of the dates of flowering of plants, and of the appearing of migratory birds. Dr. Somers exhibited and described a sponge obtained by Mr. Andrew Sullivan, one of our fishermen, at the neighbouring fishing village of Herring Cove; it has not yet been identified with any described species. Mr. H. Piers gave valuable notes on Nova Scotian Zoology. Dr. Henry Ami, of the Dominion Geological Survey, contributed an account of a collection of silurian fossils from Cape George, Antigonish County, with descriptions of three new species. Dr. R. W. Ells gave notes on sedimentary formations on the Bay of Fundy coast. Mr. W. H. Prest's Observations on Deep Mining in Nova Scotia concludes our catalogue of papers read during the Session of 1893-94.

At the thirteenth meeting of the Royal Society of Canada, held in May, 1894, the Institute was represented by our Vice-President, Dr. A. H. MacKay, who presented a report of our operations during the year; this has been printed in the Royal Society's Minutes of Proceedings for 1894, pp. XXVII-XXVIII.

Having thus briefly dealt with the work of the session just closed, I may be permitted as an old member to extend my remarks to the circumstances under which the Institute originated more than thirty years ago, although the time now available will not admit of more than a mere glance at its early history and progress.

This Institute was originally organized in the winter of 1862-63, the former being the year of the London International Exhibition. Long before that time the Mechanics' Institute formed a centre of scientific and literary life in the City of Halifax, but it had then ceased to exist, leaving its museum as a memento in the old building of Dalhousie College. About the time when the proposal to hold the London Exhibition of 1862 was announced, it was felt here that it would be of substantial advantage to the Province to make known its resources and products to the world, and this International Exhibition seemed to offer a fitting opportunity for doing so. It was accordingly determined to collect and forward a suitable contribution of specimens to the exhibition. This was a new kind of work in Nova Scotia; the task proved an arduous one,

although the government was liberal in providing the means for obtaining what money could purchase, and those who were engaged in carrying out the work felt especially the need of scientific help in placing the products of the country before the nations of Europe. Thus was suggested the great want of some permanent organization to foster the scientific spirit in Nova Scotia. A society had been recently formed for the reading of literary papers. Some of the more active members were now engrossed with the arrangements for the Nova Scotian exhibit in London, and the literary society readily gave place to an organization of a scientific kind under the name of the Nova Scotian Institute of Natural Science. The inaugural address was delivered by PHILIP CARTERET HILL, D. C. L., President, who died rather suddenly at Tunbridge Wells in September last, and to whose memory there is an appreciative notice in the last issued number of the King's College Record. As mayor of the city, provincial secretary and premier of the Province, and in other important positions, he took an active part in civic and Provincial affairs. He afterwards removed to England, and during his residence there had been engaged in religious and philanthropic work, occasionally also contributing to the literary journals. He is pleasantly remembered by many citizens of Halifax as a genial, benevolent, scholarly, Christian gentleman.

In his inaugural address, at the first meeting of the Institute, Dr. Hill pointed out that however great the ardor or untiring the efforts of individual laborers in science might be, their isolated labors would really tend but little to enlarge the boundaries of human knowledge. Communication with each other, every laborer in the field casting his contribution into a common receptacle, whence all could freely draw, could alone give those results of individual effort their highest value. "It is then," he said, "to aid in this important work, and to afford a well constructed and organized channel for the contributions to the general stock of knowledge of those among ourselves who are interested in the fascinating fields embraced in the term 'natural science,' that the Nova Scotian Institute has been established. Should our hopes not be disappointed, we look forward to the time when our 'Transactions' shall be exchanged with older and more important institutions, and any new and well authenticated fact, having passed the ordeal of our own local organization, shall be transmitted to the great centres of science, and become the property of the whole world. * * The object of the Institution is to stimulate effort, and to aid and encourage the student by giving a recognized position and permanency to the results of his labors. If we

succeed, in however limited a measure, in effecting this object, our intention in founding the association will be fulfilled, and our humble efforts for the promotion of science and the elevation of our native land will be abundantly rewarded." The Hon. Dr. Hill could hardly have expected then that these prophetic utterances would have been so fully realized as they were in his own lifetime, for, owing to the strenuous exertions of some of our members, chiefly I believe Dr. MacGregor and Mr. Maynard Bowman, there is now no country under the sun whose scientific societies (where such exist) do not have our Transactions on their library shelves as exchanges for their own. The exchange list presented this evening shows that our annual distribution of Transactions to such libraries throughout the world amounts to upwards of seven hundred copies.

While sentiments such as those expressed in Dr. Hill's address were entertained by the organizing members who looked to the Institute they were creating as an association for the promotion of pure science, it was no doubt felt, on the other hand, by the business or more practical classes of the community, that the want of home information in regard to our industrial resources in general, and our mines and minerals particularly, was a great evil, restraining the progress of our industries,—for coal mining was going on apace, iron was being produced at Londonderry, gold had been discovered at Tangier, and was being picked up in other places along the Atlantic coast. Such memoirs on the new mineral industries as had been prepared, either by native scientists or professional miners, were then necessarily published beyond the Province. Thus, in a paper by Prof. How of King's College, read to the Institute on the 4th April, 1864, on iron ores, he remarked: "Many facts have been given in original papers by myself, and others, published almost exclusively out of the Province, during the last few years, and are scattered through the pages of various periodicals; * * * and I propose, now that an Institute of Science exists in the Province which has a prospect of permanence and an established system of publication of its Transactions, to offer for the consideration of its members, from time to time, such notes on the minerals of Nova Scotia as I hope will be acceptable and useful."

For thirty-two years the work of the Institute has gone steadily on. The monthly meetings have been regularly held; the channel for publication of scientific papers has been maintained; the fasciculus of them under title of Transactions has been annually issued, and of late years we have been able to illustrate papers more freely.

Many who took part in the work during the early period of the Institute's history have passed away; their names will not be forgotten. The papers they have left behind in our Transactions will be consulted and quoted by the generations to come of students working in the several departments to which they relate. Others have come in from time to time to take the places of those who dropped out of our ranks year by year, and, while we cannot boast of any great increase in our band of laborers, yet the Institute remains in an active state, annually turning out a certain amount of substantial work, and exercising, we trust, a healthy intellectual influence in the community.. The proceedings at our monthly meetings may be of limited interest to the general public, but our door is always open to any who care to hear what progress is being made in matters of science in which our Province is interested. We are accumulating by exchange a reference library that will be of great service for future work, and we are only waiting for the necessary building accommodation to assist in filling up the collections of our Provincial Museum, so as to make them an adequate representation of the natural wealth of the Province, and afford to our own people and to visitors from abroad a view of our mineral, agricultural, forest, fisheries, shipping and manufacturing industries commensurate in some measure with their growing importance.

In conclusion, I would like to call attention in a prominent manner to the fact that we are no longer limited to the domain of *natural science*. With an abbreviation of name made some years ago to that of the Institute of Science, we extended our range so as to embrace all departments. Our membership has not in consequence increased in the proportion that might have been expected. Almost every kind of industrial work nowadays, except mere manual labor, requires, on the part of the worker, some acquaintance with scientific facts and principles, and, in certain cases, regular scientific training. With our advanced civilization and industrial development, surely there must be more persons in this Province devoting some portion of their time to scientific work than those whose names are inscribed on the membership roll of the Institute of Science. To all such we extend a hearty invitation to come and join us!

On motion of Dr. Somers, a vote of thanks was presented to the President for his services during the past session.

The Treasurer's report was read, and having been audited and found correct, was received and adopted.

The report of the LIBRARIAN shewed that a considerable number of Scientific Societies and other Institutions had been added to the Exchange List during the past year. The following is a statement of the number of scientific and other institutions, including societies, universities, government scientific offices, libraries, etc., to which the Transactions are sent, and from which exchanges have been received:

	NUMBER OF INSTITUTIONS	
	To which Transactiohs are sent:	From which exchanges are rec'd:
Great Britain and Ireland	126	59
France	62	21
Germany	87	57
Russia	18	11
Austria-Hungary	23	10
Norway	12	11
Sweden	11	6
Belgium	14	4
Netherlands	9	4
Italy	34	18
Switzerland	15	8
Servia	1	0
Spain	2	0
Portugal	1	0
Denmark	5	2
India	8	2
China	2	0
Malta	1	0
Mauritius	1	0
Straits Settlements	0	1
Japan	2	1
South Africa	2	1
Australasia	34	20
Brazil	3	1
Chili	1	1
Argentina	4	4
British Guiana	1	1
Central America	2	2
Mexico	4	4
West Indies	4	1
United States	156	96
Newfoundland	1	0
Canada (exclusive of Nova Scotia) ... 41 Nova Scotia ... 22	63	37
Totals	709	383

The large excess in the number of institutions to which we send, over the number which send to us in return, is not due to reluctance on the part of other societies to exchange with us, but to a small extent to the fact that it has not yet been found possible to correspond with all the societies which we wish to have on our exchange list, and to a large

extent to the fact that we send our Transactions to a large number of institutions, such as libraries, museums, etc, which issue no publications which they can send us in return. In Canada, for example, all libraries of whose existence we are aware are placed upon our distribution list.

Seventy-five volumes,—all being publications in English,—have been completed and bound during the year, Many others have been completed, but have had to be left unbound owing to lack of funds.

So far as utility to members is concerned, the library still suffers from the inconvenience of its quarters, The greater part of it is in cases in a corridor of the Post Office building, the rest is in a room courteously furnished for the purpose by the Governors of Dalhousie College. The library is well arranged, so that the librarian can without difficulty obtain any book which may be desired. But the lack of a catalogue, and the hesitation of members to trouble the librarian to meet them either at the Post Office or at the College, prevents members from putting the library to its full use. It is to be hoped that, before very long, the Institute may be able to afford to possess rooms of its own, with a paid secretary and librarian, or that the scheme for the consolidation of the Legislative and other libraries in the city, and the provision of a building to accommodate both them and the Provincial Museum, which has been urged upon the local government for some time, may be carried out at an early date.

The following were elected office-bearers for the ensuing year :—

President—PROFESSOR GEORGE LAWSON, LL. D.

Vice-Presidents—ALEX. MCKAY, ESQ., and EDWIN GILPIN, JR., ESQ., LL. D.

Treasurer—W. C. SILVER, ESQ.

Corresponding Secretary—PROF. J. G. MACGREGOR, D. SC.

Recording Secretary—HARRY PIERS, ESQ.

Librarian—MAYNARD BOWMAN, ESQ.

Councillors without office—A. H. MACKAY, ESQ., LL. D.; MARTIN MURPHY, ESQ, D. SC.; A. P. REID, ESQ., M. D.; F. W. W. DOANE, ESQ., C. E.; WILLIAM MCKERRON, ESQ.; JOHN SOMERS, ESQ., M. D.; WATSON L. BISHOP, ESQ.

First Ordinary Meeting.

Provincial Museum, Halifax, 12th November, 1894.

The President in the chair.

Much time having been occupied by the annual business meeting which had just adjourned, the reading of papers was deferred until the next meeting.

Second Ordinary Meeting.

Legislative Council Chamber, Halifax. 10th December, 1894.

The President in the chair.

It was announced that the following had been duly elected members :—W. H. Prest, Esq., Chester Basin, N. S. ; Rev. W. M. Fraser, B. A., B. Sc., Halifax ; W. H. Magee, Esq., Ph. D., High School, New Glasgow ; E. E. Faville, Esq., Director, N. S. School of Horticulture, Wolfville ; Rev. James Rosborough, Musquodoboit Harbour ; Alexander Dick, Esq., Halifax ; C. E. Willis, Esq., M. E., Halifax ; L. H. Wheaton, Esq., Chief Engineer, Coast Railway Company, Yarmouth.

A paper by Prof. L. W. Bailey, entitled, "Notes on the Geology and Botany of Digby Neck," was read by the Corresponding Secretary. (See Transactions, p. 68.)

Dr. A. H. MacKay read a paper on "A Foraminiferous Deposit from the bottom of the North Atlantic." (See Transactions, p. 64.)

Third Ordinary Meeting.

Legislative Council Chamber, Halifax, 14th January, 1895.

Alexander McKay, Esq., Vice-President, in the chair.

It was announced that C. F. Hall, Esq , and H. W. Johnston, Jr., Esq., C. E., of Halifax, had been elected ordinary members, and F. H. Mason, Esq, F. C. S., an associate member.

Dr. MacKay presented "Additional Notes on Globigerina Ooze and Stones obtained by the S. S. 'Minia' from the bottom of the North Atlantic." (See Transactions, p. 64.)

A paper by T. C. WESTON, Esq., F. G. S. A., entitled, "Notes on Concretions found in Canadian Rocks," was read by the CORRESPONDING SECRETARY. (See Transactions, p. 1.)

On motion of DR. MACGREGOR and MR. FORBES, it was—

Resolved, That the Institute express its deep appreciation of the great services which MR. ALEXANDER MCKAY has rendered it in his discharge of the duties of Recording Secretary for a period of fourteen years; and that as a mark of its appreciation of his services, the Institute elect Mr. MCKAY to Life-membership, without payment of the usual fee.

FOURTH ORDINARY MEETING.

Church of England Institute, Halifax, 11th February, 1895.

ALEXANDER MCKAY, Esq., VICE-PRESIDENT, in the chair.

DR. GILPIN, Inspector of Mines, read a paper entitled, "The Iron Ores of Nictaux, N. S., and Notes on Steel-making in Nova Scotia." (See Transactions, p. 10.)

In the discussion which followed DR. A. H. MACKAY gave a popular description of this region which he illustrated by means of a large outline map. Starting from the Railway Junction of Middleton and following the railway across the Annapolis Valley for four miles in a southerly direction, over the sand and gravel which rest on Triassic beds, one arrives at the foot of the South Mountain range, where the Nictaux River in its course nearly magnetic north, debouches from its rocky gorge channelled through the Highlands. From Nictaux Falls station the railway enters into the gorge, creeping higher and higher along its western side. Just at the foot of the hills upper silurian slates appear to show themselves, and the railway cuts every now and then great dykes of igneous rock which at various times rent the slates in numerous fissures. Two miles up from the falls, in what appear to be of lower Devonian age, the river and railway line at Cleveland cut at an oblique angle, approximately vertical strata of magnetic iron ores generally highly siliceous. One mile further up, and the road passes through a great intrusive granite belt about a mile in width. Then comes a great rock excavation through a bluff of very hard slates, when the course is again in the granite and tending south-westerly to Alpena Station, six miles above the Falls. During the two weeks he was in this district, he

studied the country to the west of the Nictaux as far as Jones' Brook, and to the east as far as Tor Brook. The iron strata at Cleveland appear to show themselves to the south-west near Jones' Brook over two miles distant and beyond the mile belt of intrusive granite. To the north-east of Cleveland, for a distance of four miles, there are several outcrops of probably the same strata, the iron of which is hæmatitic instead of magnetic. At the north-eastern end of this line which runs parallel with the course of the Tor Brook for over two miles, are the Tor Brook Mines, where a large quantity of valuable hematite was being mined. This iron belt then appears to be at least six miles long, cutting the general magnetic north and south course of the Nictaux at Cleveland, as a line running from the south-west (declining to the west) two miles across the granite ridge referred to, to Tor brook, four miles to the north-east.

Allusion was made to the interesting character of the geological problem, to which our two greatest geologists have been giving different solutions. Sir Wm. Dawson thought the palaeontology of the iron beds would place them as high as the Oriskany, the base of the Devonian, and therefore higher than the rocks near the Nictaux Falls which might be Lower Helderberg and Niagara (Upper Silurian). Dr. Honeyman would put the iron beds lower even than the Niagara—as low as the Clinton if not the Medina. Collections of fossils were made at various points which had not then been examined, so that he would not venture to say whether later observations would justify any radical modification of the earlier hypothesis or not. The railway cuttings as well as mining explorations made in late years give geologists much better facilities for the complete study of the problem. But with all the new facilities the original hypothesis does not appear to be substantially disproved.

Observations were also made on surface geology. Glacial erosion was widely exhibited, and in at least one section of a drift bank cut by the railway there was evidence of an older drift from north to south, as well as a later from south to north, down the slope of the land to the Annapolis Valley.

Fifth Ordinary Meeting.

Church of England Institute, Halifax, 11th March, 1895.

The President in the chair.

It was reported that Miss Bertha Elliot, Superintendent of Nurses, Victoria General Hospital, had been elected an ordinary member, and S.

S. DICKENSON, Esq., Superintendent of the Commercial Cable, Hazelhill, Guysborough County, N. S., had been elected an associate member.

PROF. FAVILLE, Director of the N. S. School of Horticulture, delivered a lecture on "Some Important Scientific Problems in Horticulture," illustrated by a number of charts.

SIXTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 15th April, 1895.

The PRESIDENT in the chair.

It was reported that the HON. MR. JUSTICE WEATHERBE had been elected a member.

The following paper by MISS LUCY C. EATON, entitled, "The Butterflies of Truro, N. S.," was read by Mr. Piers :

1. *Vanessa antiopa*, L.—Very beautiful specimens of this butterfly are on the wing during the last of July. A full grown larva captured on the 11th of July, 1894, went into cocoon on the 12th and appeared as a perfect insect on the 26th of the same month. This species hibernates during the winter and appears in spring with its wings much worn and faded.

2. *Vanessa milberti*, Godt.—Also a hibernating species, and like the *antiopa*, common here.

3. *Argynnis atlantis*, Edw.— Very common. Is with us the greater part of the summer.

4. *Argynnis myrina*, Cram.—Not very common.

5. *Argynnis cybele*, F.—Not common.

6. *Papilio turnus*, L.— Our largest butterfly. Rare because of natural enemies.

7. *Pieris oleracea*, Harr.— Native cabbage butterfly. Not very common.

8. *Pieris rapæ*, L.—Imported cabbage butterfly. Very common.

9. *Colias philodice*, Godt.— Clover butterfly. Quite common; may be seen during the greater part of the summer.

10. *Melitæa phæton*, Drury.—Very rare.

11. *Phyciodes tharos*, Drury.—Not very common.

12. *Phyciodes nycteis*, Doub.—Not common.

13. *Grapta progne*, Cram.—Not common.

14. *Grapta faunus*, Edw.—Not common.

15. *Grapta J-album*, Bd.-Lec.—Very rare.

16. *Limenitis arthemis*, Drury, (form *lamina*, F.)—Not common.

17. *Limenitis disippus*, Godt.—Not common.

18. *Neonympha canthus*, L.—Not common.

19. *Satyrus alope*, F.—This is a forest species and somewhat rare.

20. *Satyrus nephele*, Kirby.—Quite rare.

21. Intergrades between *alope* and *nephele*.

22. *Chrysophanus americana*, D'Urban.—This pretty little butterfly is very common, and is with us during the greater part of the summer.

23. *Pamphila mystic*, Edw.—Not common.

24. *Pamphila cernes*, Bd.-Lec.—Not very common.

25. *Lycæna lucia*, Bd.-Lec.— This beautiful little butterfly is very rare here. I have only captured one. It was taken in Victoria Park.

26. *Lycæna violacea*.—This species is also rare.

In reading the above paper, Mr. Piers made a number of observations upon the subject:

If the species named in the list had been correctly determined, he thought it would prove an interesting addition to our knowledge of the Lepidoptera of the province. All previous catalogues have emanated from Halifax, and carefully prepared local lists from other parts of the province, especially from the western section, are necessary before a full account of our butterflies can be presented.

An examination of Miss Eaton's paper suggests that more thorough search will doubtless show that many of the species mentioned therein as uncommon, are really generally less rare than stated in her notes. The many species spoken of as not common, and a comparison with the the relative abundance of the same species about Halifax and elsewhere in the eastern part of the Dominion, prompts such a surmise. In some cases the difference between the abundance of various species in this locality and in the Truro district, is doubtless a local difference, and therefore of great interest. There is no doubt that many species frequently met with in the western parc of the province, are rare or even unknown on the Atlantic coast, and *vice versa*. For this reason, reliable annotated lists of species occurring at various stations throughout Nova Scotia are absolutely necessary before we can present a correct statement of the general abundance of the various species throughout the whole province.

Comparison with the catalogues of Belt, Jones, and Silver, makes it probable that a number of other species will yet be reported from Truro. The *Lycænidæ* and *Hesperidæ* will doubtless furnish many representatives. The speaker was surprised at not finding in the list a few species which are common about Halifax, and whose occurrence at Truro might be expected. For example, *Pyrameis cardui* is common near this city, as well as generally throughout the eastern provinces of Canada, while *P. huntera* is abundant some years whilst rare in others. *P. atalanta*, which Belt and Jones considered rare or not common, Mr. Piers has found plentiful about Halifax where it has doubtless become more common during recent years owing to the increase of food. *Danais archippus*, although rare near Halifax, was said by the late Mr. Downs, on the authority of Mr. John Winton, to be not so rare along the valley of the Shubenacadie. Search should be made for all of these species in the vicinity of Truro.

Mr. Piers also made the following remarks upon a few of the species mentioned in Miss Eaton's paper:

Vanessa milberti. Both Belt and Jones reported that this species had been taken at Truro and Windsor, but had not been observed near Halifax. It is included in Mr. Silver's recent list (*Trans. N. S. I. N. S.*, vol. VII.)

Argynnis atlantis. This species, which resembles *aphrodite*, does not appear in the lists of Belt, Jones, or Silver, but Rev. C. J. S. Bethune

(" Butterflies of Eastern Provinces of Canada," 1894) says that it occurs in Nova Scotia, as well as in Cape Breton, Prince Edward Island, and New Brunswick. It is common throughout northern Ontario and Eastern Quebcc.

Argynnis myrina. Reported as not very common at Truro. It is a very common species about Halifax.

Argynnis cybele. This species does not seem to have been definitely reported from Nova Scotia proper,* but in Rev. C. J. S. Bethune's list of the butterflies of eastern Canada, (Rept. Ent. Soc. of Ont., 1894) we find it mentioned as having been taken in Cape Breton and Prince Edward Island. Its occurrence at Truro, if it has not been confounded with *A. aphrodite*, is interesting. *A. cybele* is very similar to this last-mentioned species. *A. aphrodite* is abundant near Halifax, and has been reported by Belt (?), Jones, and Silver, but it is not mentioned in the Truro list. This gives rise to a suspicion that some of the Truro specimens, upon re-examination, may prove to be *aphrodite.* It is very probable, however, that we have both species in Nova Scotia, and the attention of our entomologists is drawn to the subject. Specimens in Mr. Piers's own collection, taken in the vicinity of Halifax, are undoubtedly *aphrodite.*

Papilio turnus. Common at Halifax, but reported rare by Miss Eaton.

Militœa phaeton. As far as known, this species has hitherto been reported from but one spot in the Province, namely a meadow not far from Bedford Rifle Range, near Halifax. Its appearance in the Truro list is of great interest.

Phyciodes tharos. Very common near Halifax and elsewhere throughout the eastern provinces of Canada.

Phyciodes nycteis. In Canada this species has only been collected in Ontario and Quebec, where it is not common. Have the specimens mentioned in the previous list, been correctly referred to this species? Its occurrence in Nova Scotia is somewhat unexpected.

Grapta faunus. Rev. C. J. S. Bethune notes its occurrence in Nova Scotia (" Butterflies of EasternProvinces of Canada," *Rept. Ent. Soc. of*

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* Consult, however, Mr. Belt's remarks in *Trans. N. S. I. N. S.*, vol. i, pt. 2, p. 89. from the wording of which it is possible that he had found both *aphrodite* and *cybele* in the province.

Ont., 1894). Consult also Mr. Belt's notes on pages 90-91of his paper (*Trans. I. N. S.*, vol i, pt. 2).

Neonympha canthus. Not mentioned by Mr. Belt or Mr. Silver, but Mr. Jones reports it, under its synonym *Neonympha boisduvallii*, as having been taken by Mr. John Winton at Lower Stewiacke, Colchester County. A specimen from that locality was in Mr. Jones's collection.

Lycæna lucia and *violacea* (winter forms of *L. pseudargiolus*). Miss Eaton speaks of these forms as rare at Truro. The species is very abundant about Halifax in the spring, and is familiar to trout fishermen under the common name "Jenny Lind."

DR. MARTIN MURPHY, Provincial Engineer, read a paper entitled, "A Cheap and Effective Bicycle Track for Rough Country Roads," which was followed by an interesting discussion.

SEVENTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 13th May, 1895.

ALEXANDER MCKAY, Esq., VICE-PRESIDENT, in the chair.

It was announced that MELVILLE G. DEWOLFE, Esq., of Kentville, N. S., had been elected an associate member.

The report of the Institute, to be presented by DR. SANDFORD FLEMING at the forthcoming meeting of the Royal Society of Canada, was read by the Secretary.

HARRY PIERS, Esq., read a paper entitled, "Relics of the Stone Age in Nova Scotia." The paper was illustrated by a collection of stone implements and drawings. (See Transactions, p. 26.)

A paper by REV. ARTHUR WAGHORNE of St. John's, Newfoudland, on the "Flora of Newfoundland, and S. Pierre et Miquelon," was read by title. (See Transactions, p. 83.)

DR. A. H. MACKAY, Superintendent of Education, presented a paper entitled, "Phenological Observations made during 1894." (See Transactions, p. 59.)

WATSON L. BISHOP, Esq., exhibited a specimen of quartz, one side of which was flat and striated. It had been found by Mr. J. R. Glendinning about six feet below the surface in an earth cutting by the roadside at the foot of the First Lake, Dartmouth, N. S.

The following papers were read by title :—

"Note on Coal Gas as a Probable Source of Argon." By PROF. G. LAWSON.

"On the Visibility of Mercury to the Naked Eye." By A. CAMERON, Esq., Principal of Yarmouth Academy.

"Tidal Erosion and Deposition in Minas Basin." By PROF. A. E. COLDWELL, Acadia College, Wolfville, N. S.

"True Surfaces and Accurate Measurements." By D. W. ROBB, Esq., A. S. M. E, Amherst, N. S. (See Transactions, p. 21.)

A bound copy of CAPT. TROTT's paper on Submarine Cables was presented by the author to the library of the Institute.

HARRY PIERS,
Recording Secretary.

Members of the Institute, and Societies in correspondence with it, would confer a great favor if they would send to the Council, for distribution to Scientific Institutions whose sets of the Institute's publications are incomplete, any duplicate or other spare copies which they may possess of back numbers of its Proceedings and Transactions. They should be addressed : *The Secretary of the N. S. Institute of Science, Halifax, Nova Scotia.*

THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science,

HALIFAX, NOVA SCOTIA.

SESSION OF 1895-96.

VOLUME IX

(BEING VOLUME II OF THE SECOND SERIES)

PART 2.

WITH A PORTRAIT AND THREE PLATES.

The First Series consisted of the Seven Volumes of the Proceedings and Transactions of the Nova Scotian Institute of Natural Science.

PRICE TO NON-MEMBERS: ONE HALF-DOLLAR.

HALIFAX:
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ERRATA.

P 130.- The numbers in the third column of the first table should be multiplied by the ratio of the number of gramme-molecules of Sodium Chloride to the number of gramme-molecules of Potassium Chloride, in the corresponding constituent solutions.

P. 132.—The numbers in the fourth column of the table should be multiplied by the ratio of the number of gramme-molecules of Sodium Chloride to the number of gramme-molecules of Hydrochloric Acid in the constituent solutions.

George Lawson

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1895-6.

Annual Business Meeting.

Legislative Council Chamber, Halifax, 11th November, 1895.

The first Vice-President, Alexander McKay, Esq., in the chair.

On opening the meeting the chairman announced to the Institute the sudden death of its late President, Prof. George Lawson, Ph. D., LL. D., which had occurred on the previous evening at his residence in Halifax.

After reference had been made by the chairman and other members of the Institute to the great loss which the Institute had sustained, it was unanimously resolved that the Institute, as a body, should attend the funeral of its late President.

It was further unanimously resolved that, as a mark of respect to the late President, the Annual Meeting should be adjourned until the 18th of November.

Legislative Council Chamber, Halifax, 18th November, 1895.

Alexander McKay, Esq., Vice-President, in the chair.

Prof. J. G. MacGregor, Corresponding Secretary, addressed the Institute as follows :

Mr. Vice-President,—It is my duty, on this occasion, to bring before the Institute some account of the life and work of members deceased

during the past year. Until the last evening prior to the date fixed for the annual meeting, we could say that death had made no diminution in our list of members. But, on that evening, we lost one who was *facile princeps* among us—our late President, Prof. George Lawson.

Prof. Lawson was born on the 12th October, 1827, at Newport, Fifeshire, in Scotland. He was the son of Alexander Lawson and belonged to a family which had long resided in Fifeshire. After completing his school education, he entered upon the study of law; but his strong natural taste for scientific work led him to abandon a legal career, and to enter the University of Edinburgh with the object of studying the natural and physical sciences. His studies in Edinburgh extended over a period of ten years, during which time he was also occupied with scientific and literary work in connection with the University and with several of the scientific institutions of that city. He was for a time Curator of the University Herbarium, and was thus brought into either personal contact or correspondence with the leading botanists of the time. He was also for some time Demonstrator of Botany under Professor J. H. Balfour; and, in that capacity, he conducted a select class for advanced students, teaching the practical use of the microscope and methods of research in regard to the minute structure and development of plants. The class was one of the first of the kind conducted in Great Britain. The preparation of the Catalogue of the Library of the Royal Society of Edinburgh was entrusted to him at this time, and was carried out to the great satisfaction of the Society. He acted also as secretary of several societies, in particular of the Royal Physical Society, in which office he had as colleague the late Sir Wyville Thomson, afterwards Chief of the Scientific Staff of the *Challenger* expedition.

In the year 1858 he was appointed to the Professorship of Chemistry and Natural History in Queen's University, Kingston, Ontario, and, to the great regret of the leading scientific men in Edinburgh, evidenced by their presenting him with an address, a silver salver and a purse of sovereigns, he accepted the appointment.

In 1863, on the reorganization of Dalhousie College in this city, Dr. Lawson resigned his chair at Queen's College and accepted the Professorship of Chemistry and Mineralogy here. From that date until the present—for a period of thirty-two years—he has conducted the chemical department in this college. In addition to the work of his chair, he also for many years conducted a class in Botany.

During his residence in Halifax he was always ready to give assistance to struggling educational institutions. For years he delivered courses of lectures in Chemistry and Botany to the students of the Halifax Medical College. He was one of the organizers of the Technological Institute ; and when that useful evening school ceased to exist through lack of funds, he conducted for some years, and intended to conduct periodically, an evening class in theoretical and practical chemistry, especially for men engaged in chemical industries.

Soon after his coming to Nova Scotia, a Board of Agriculture was established by the government, and his previous profound study of British agriculture led to his appointment to the secretaryship of the Board. He discharged the duties of this office from 1864 to 1885, when the functions of the Board were assumed directly by the government, and he was appointed Secretary for Agriculture. His connection with agriculture was rendered still more intimate from the fact that he for many years himself conducted a farm, largely, I believe, a stock farm, at Sackville, N. S. Whether intended to be so or not, it was generally regarded as a model of what such a farm ought to be.

Shortly after his appointment to the Professorship in Dalhousie College, Prof. Lawson became a member of this Institute, and he soon became one of our most active members. He attended our meetings with the greatest regularity, and was always ready to give freely of his time and energy with the object of promoting the interests of the Society. His executive ability was early recognized, and he was elected a member of the Council in 1864. Since that date there have been but five years in which he was not so selected. He was Vice-President on nine occasions, and has held the office of President during the last two years.

During his membership he communicated in all fifteen papers to the Institute, including five which are as yet unpublished, and which, I fear, have not been finally prepared for publication. These papers are, for the most part, in the department of Botany, which, as our members know well, was his favorite subject. I may mention his "Monograph of the Ranunculaceæ of the Dominion of Canada," the paper "On the Laminariaceæ of the Dominion," the "Monograph of the Ericaceæ of the Dominion," and the papers "On Canadian Species of Rubi," "On the Northern Limit of Wild Grape Vines," and "On the Canadian Species of the Genus Melilotus," as being especially important contributions to

our knowledge of the geographical distribution of plants. The Institute was the more indebted to Prof. Lawson for publishing these papers in its Transactions, because, long before coming among us, he had gained the ear of the scientific world, and the Transactions of several of the Societies of the mother-country, which formed much better means of publication than ours, were open to him. I know that previously to the last few years, he felt very keenly the serious drawbacks connected with publishing in the Transactions of the Institute. At that time the Council rigorously demanded that no paper should be published in our Transactions which had previously appeared elsewhere, while, at the same time, little effort was made to distribute our Transactions among Scientific Societies throughout the world. Of course, also, none of the larger scientific societies or magazines would publish a paper which had previously appeared here. Papers published in our Transactions were thus, to a certain extent, buried, and authors could bring them to the notice of scientific men elsewhere only by distributing separate copies. During the last few years the policy of the Council has been changed. Our Transactions are now sent to all important Scientific Societies throughout the world, and, in addition, to a very large number of Universities, Public Libraries and Museums. A paper which is published in our Transactions, therefore, has some chance of being seen. But, besides that, in several cases recently, the Council has wisely permitted the publication of papers which had been communicated to it, previously to their appearance in our Transactions, on the simple condition of their being credited to the Institute. To a man like Dr. Lawson, who had the best avenues of publication open to him, these modifications of our policy were a great relief; for they permitted him to communicate researches to the Institute and yet to feel confident that he was not thereby hiding them away. Consequently, during the last few years, he had been able to bring a larger number of papers before the Institute than formerly, and he had projected a series of valuable papers on the Flora of Nova Scotia, which were to have been communicated to us. The first of this series was read on February 9th, 1891, and appears in our Transactions at p. 84 of the eighth volume. The second was read on the 14th December, 1891; but the manuscript required revision when our issue of that year went to press, and the burden of other duties, together with failing health, had, I fear, prevented its revision altogether.

Prof. Lawson's scientific work began in 1846, when, at the early age of 19 years, he communicated a series of papers to the *Phytologist*, embodying the results of botanical observations. From that time until the present, but few years passed in which he did not make some contribution, smaller or larger, to the advancement either of his favorite subject of Botany or some allied subject. Before coming to Canada, as already stated, he had made a distinct reputation as a botanist, having published in this department of science forty-four papers and one book, and having prepared the manuscript of a second book, which, however, through the death of one of the members of the firm which had undertaken to issue it, was never published. In addition, he had published a few papers in other departments of natural science, a work on British agriculture, and the Catalogue of the Royal Society's Library, and he had for two years issued a monthly serial containing treatises on the field crops of Britain.

During his five years residence at Kingston his scientific activity was unabated, notwithstanding the large amount of work which fell to his hands in organizing the science teaching of Queen's College. To this period belong thirteen botanical papers, one chemical paper, and one agricultural pamphlet. In this period also falls the organization of the Botanical Society of Canada, which he was largely instrumental in founding, and which, in the few years of its active existence, did good work in promoting the study of botany in Canada.

During his residence in Halifax, Prof. Lawson published thirty-one botanical papers, four on chemical subjects and one in zoology. In addition he issued the *Journal of Agriculture* for twelve years, the annual reports of the Secretary of Agriculture for thirty years, the crop reports of Nova Scotia for six years, a special report on cattle pastures. and the Nova Scotia register of thoroughbred cattle. It will be noticed that the amount of his scientific work, so far as it can be judged by mere number of papers, was smaller during the last period than in either of the others. This was of course due to the heavy demands which his duties as Secretary of Agriculture made upon his time. In the interest of pure science, therefore, his appointment to this office is to be regretted. But if we take a wider view, and consider the great services which, as Secretary, he rendered to the farming industry, it may be that the loss to pure science was balanced, and perhaps overbalanced, by the improvements in the applications of science which he was able to effect in Nova Scotia.

The total number of his communications to scientific societies, each of which represents some addition to knowledge, is as follows:—In Botany, 93; in Zoology, 4; in Chemistry, 5; and in subjects difficult to classify, 5. These, in themselves, form a far larger body of work than it is the privilege of most scientific men to have been able to execute; and when one thinks in addition of the work involved in the long series of reports, treatises, etc., of a practical kind which his pen produced, and of the articles in reviews and other periodicals and in cyclopedias, of which no mention has been made above, one begins to form some estimate of the enormous industry, patience, perseverance, and minute attention to detail, of which our late professor was capable.

A complete list of his published papers, as well as of his books, reports, etc., up to the end of 1894, will be found in the "Bibliography of the members of the Royal Society of Canada," compiled by Dr. J. G. Bourinot, and issued as part of Vol. XII of the Transactions of that Society. A list of the papers communicated to the Institute during the last four years, including six which do not appear in the Royal Society's list, will be found in the Index to Vol. VIII of our Transactions.

As to the value of his scientific work, it would be presumptuous in me to offer an opinion. He, doubtless, reached no wide generalizations. It is given to few men to do so. But he added greatly to our knowledge of plant life, and made especially large contributions to our knowledge of the geographical distribution of plants. Whether or not he possessed the ability to do what is called, in German phrase, epoch-making work, it is impossible to say; for his lot was cast in circumstances in which such work was practically impossible. But, although he was unable to pursue his investigations with the appliances and by the methods which he would have selected, had the colleges with which he was connected possessed adequate equipment, he nevertheless resolutely did what he could; and he has, consequently, left behind him a mass of useful work accomplished, which forms a *monumentum œre perennius.*

Of the value of his work as Secretary of Agriculture, it is difficult to form any estimate. It consisted not so much in the excellence of the Reports which it was his duty to issue from time to time,—though they were models of conscientious skill,—or in the judiciousness of his official communications with the Agricultural Societies of the Province,—though there is no doubt as to the ability with which these communications were conducted,—as in the quiet influence which he exerted over the

farmers of Nova Scotia, an influence which was due to a firm conviction on their part that he had their interests at heart and that he possessed a profound knowledge on which his advice to them was based. He had given great attention to agriculture, as we have seen, before coming to Canada; and, though farming is carried on under very different conditions in Great Britain and Canada, he had the rare faculty of allowing for the difference of conditions, and applying his general knowledge accurately in new circumstances, and rapidly gaining an insight into the modifications which our climate, the undeveloped state of our country, and our mode of life, made necessary. It is certain, at any rate, whether this view of its source is correct or not, that he exerted a great influence over our farming population, and that his exercise of that influence was in the highest degree beneficent.

The outward marks which show the esteem in which scientific work is held by scientific men, are received only in small measure by the retiring worker who lives far from the centres of research. Nevertheless, Dr. Lawson was not without such cheering evidence of appreciation. The degree of Ph. D. was conferred upon him by the University of Giessen, and that of LL. D. by McGill University, Montreal. He was a Fellow of the Botanical Society and of the Royal Physical Society of Edinburgh, and of the Institute of Chemistry of Great Britain, an Honorary Member of the Edinburgh Geological and of the Scottish Arboricultural Societies, a Corresponding Member of the Royal Horticultural Society of London, and of the Society of Natural Science of Cherbourg, one of the original Fellows and an ex-President of the Royal Society of Canada, and a member of various other learned societies.

The indirect influence which Dr. Lawson exerted on the progress of science in Canada was also very great. Many of the members of this Institute are old pupils of his, and can testify to the stimulating power which he could exert and did exert in the presentation of his subject. I was assured some few years ago by one of the leading botanists of Canada, that all the leading Canadian botanists of that date, who had been trained in Canada, were Dr. Lawson's pupils; and such a fact speaks volumes for the ability of their teacher. His power of rousing enthusiasm in his pupils was more marked in his teaching of Botany than in his teaching of Chemistry; for, though the latter was the principal subject of the Professorships which he held, the former

was the subject in which he delighted. It was, perhaps, also more marked in former than in later years, the burden of the many duties which, owing to his thorough knowledge of Agriculture, had been forced upon him, having been too great, apparently, for his intellectual elasticity. But that the power was there in great measure, there can be no doubt, and that it was exercised even in later years is shown by the fact that we have had botanical communications recently from pupils of his who have only lately left the class-room.

The indirect influence which is shown in kindly interest and considerate criticism, is familiar to all our younger members, who have been endeavoring themselves to engage in research, or who have brought the results of their research before the Institute. We well know that he was always interested even in the smallest of our contributions; that when he directed our attention to faults which might be removed, it was always in the gentlest manner and with the utmost courtesy and consideration for the feelings of others; and we know also, that in any of the many subjects with which he was familiar, he was always ready to draw from his store of information, for our benefit, things either new or old. His readiness at all times to work for this Institute, his labours in connection with the Botanical Society of Canada, the interest he took in the recently founded Botanical Club, his willingness to contribute to the maintenance even of local scientific societies in distant parts of the Dominion, were simply instances of the very large indirect influence which he exerted on the progress of science in Canada.

This short statement can give but a feeble account of the great work which our late President was able to accomplish in the advancment of Science, the upbuilding of this Institute, and the development of of his adopted country. It may serve, however, to show that through Dr. Lawson's death, the Province of Nova Scotia loses a man who, owing to his profound knowledge and his public spirit, was able to exert a large influence on the development of its most important industry; the Institute loses a member who, through his activity and success in research, has been largely instrumental in making the reputation which it now possesses in the estimation of similar societies in other parts of the world, and we all, personally, lose a friend who, through his kindly courtesy and readiness to help, had won our deep affection and profound esteem.

On motion of DR. SOMERS, seconded by DR. MURPHY, it was unanimously resolved that the Secretary be directed to transmit to the family of its late President, PROF. G. LAWSON, an expression of the Institute's deep sense of the great value of his scientific labours and of the eminent service which he had rendered to the Province of Nova Scotia, together with an assurance of the very warm sympathy felt by the Institure with his family in their sad bereavement.

It was further resolved that the Corresponding Secretary's account of the Life and Work of the late President should be published in the Proceedings, and that it should be accompanied by a portrait.

MR. HARRY PIERS, RECORDING SECRETARY, read the following report:—

Mr. Chairman and Gentlemen,—In the absence of the usual Presidential address, I have been requested to prepare a short review of the work of the Institute during the past session. I fear, however, that my scanty observations will be but a very sorry substitute for the remarks of him who, under other circumstances, would have this evening filled the chair.

It is with much sorrow I refer to the recent death of one with whom we all were familiar and whom we all respected. In the sudden death of its President, the Institute has lost one of its most active workers and one whose name lent a lustre to its ranks. The name of Dr. Lawson will be unforgotten, not only by his fellow-workers in the science which he held so close to his heart, but also by every man of the Province in which he was so well known.

The few words in which I have referred to the Society's loss, are few because of my inability to properly deal with the deceased gentleman's life and work. In this relation, however, we have just heard the opinions of one better qualified than myself to do justice to his standing as a scientist and a man.

With this notable exception, I am pleased to be able to say that since the opening of the last session the Institute has lost no members, either by death or withdrawal. During the past twelve months, fifteen members have been added to our number,—with one exception the largest annual addition for many years. Of these, ten are ordinary members residing in the city, while five are associates, one of whom

has paid a life composition fee. Five gentlemen out of the fifteen have not yet paid their first fee, and therefore are not entitled to the full privileges of membership. The roll-book at present bears the names of 126 members. This list, however, much needs revision. Several of he gentlemen named therein have neither cancelled their arrears nor even shown interest in the work of the Society by attending its monthly meetings. Owing to this lack of revision, our Proceedings and Transactions are furnished gratis to some who in no way advance the objects for which the Institute was formed.

During the session of 1894–5, the full number of eight meetings was held, the annual business meeting taking place, for the sake of convenience, on the same date as that of the first monthly one. Eighteen papers were presented at these meetings. They may roughly be classed under the following heads : presidential address, 1 ; archæology, 1 ; phenology, 1 ; zoology, 2 ; geology, 6 ; botany and horticulture, 2 ; chemistry, 1 ; astronomy, 1 ; mechanics, 2. These papers were contributed by fourteen persons,—that is to say only about eleven per cent. of the members laid work before the Society. This is a decrease from the previous session of 1893-94, when twenty-two papers were presented by eighteen persons, or sixteen and a half per cent. of the list of members as it then stood (about 109). Of the one hundred and twenty-six living members, I find that thirty-two (or nearly twenty-six per cent.) have at some time contributed one or more papers. Several of these, however, have furnished nothing for many years. At the present time, only about eighteen members can be spoken of as representing the working force of the Institute. There are many, however, who could easily prepare papers, but they have not yet done so.

Several branches of our natural history have, so far, been entirely neglected ; but it is to be hoped that these will be worked up before many years. Several entomological orders offer a tempting field in this respect.

The attendance at the monthly meetings of the society probably averages about twenty-two. Large meetings cannot, of course, be expected when the results of special research are being presented. Popular papers are more attractive to the public ; but, on the other hand, are less acceptable for publication. A larger attendance of teachers

might well be expected. Although invitations are regularly sent to the Principals and other teachers of nearly every school in Halifax and also to the staff of the Dartmouth schools, and although all are thus welcomed to our meetings, yet only about five teachers are at all regular attenders and only two of these have taken advantage of the Institute's general invitation. When we consider the number of teachers who are employed in the city and in Dartmouth, and the prominence which is given to science in the public schools, this lack of interest is a manifestation which we would hardly expect. Of course, more elementary lectures would no doubt attract a larger number.

Invitations are also sent to the various military departments; but a lack of interest is there also shown—a very different condition from the time when the Institute numbered among its most active members many officers of the army whose names are well known to us all. Nevertheless the Institute is in a most healthy state, the most urgent need being a proper room to contain the library, which at present is only semi-accessible.

I am glad to say that the finances of the Society are in an excellent standing. This is largely due to the liberality of the provincial government.

The Transactions for the session of 1893–4 have been distributed, and the Part for last session is going to press.

I regret that the foregoing report is not less meagre, and, with yourselves, am sorry that an address had not been prepared by one fully qualified to analyse the work of the Institute and to offer valuable suggestions for its better management. I hope, however, that my few remarks have not been wholly without interest.

It was resolved that the Report of the RECORDING SECRETARY should be published in the Proceedings.

The Report of the TREASURER, which had been audited by Messrs. R. McColl, C. E., and S. A. Morton, M. A., was read and adopted, and, on motion, it was resolved that a statement of the receipts and expenditure for the year should be printed and sent to members.

The Report of the LIBRARIAN shewed that during the past year copies of the Proceedings and Transactions had been sent for the first

time to twenty-six scientific institutions, and that publications had been received for the first time from thirty-one such institutions, viz., from :—

The Public Museum of the City of Milwaukee, U. S. A.
The Dundee Naturalists Society, Dundee, Scotland
The University of Illinois, Urbana, U. S. A.
The Royal Society of Queensland, Brisbane, Australia.

The North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

The Field Columbian Museum, Chicago.

The Natural Science Association of Staten Island, N. Y., U. S. A.

The Montana Society of Civil Engineers, Montana, U. S. A.
The Case School of Applied Science, Cleveland, U. S. A.
The Dulwich College Science Society, Dulwich, England.
The Public Library of the City of Boston, U. S. A.
Departmento Nacional de Estadistica de Costa Rica, San Jose.
Naturwissenchaftlicher Verein an der Universität, Vienna.

The Astronomical Observatory of Harvard College, Cambridge, U. S. A.

K. Sächsische Gesellschaft der Wissenschaften, Leipzig.
The University of Tennessee, Knoxville, U. S. A.
Musée D'Histoire Naturelle, Paris.
The Government Observatory, Madras, India.
Observatorio Astronomico y Meteorologico, San Salvador.
The Berwickshire Naturalists Club, Alnwick.
The University, Leipzig.
Comision Geologica de Mexico, Mexico.
Société Linnéenne du Nord de la France, Amiens.
The South African Museum, Cape Town.
The Iowa Academy of Science, Desmoines, Iowa, U. S. A.
Sociedad Meteorologica Uruguaya, Montevideo.
The Edinburgh Mathematical Society, Edinburgh.
The Gordon College Museum, Geelong, Australia.
K. Museum für Völkerkunde, Berlin.
The Natural History and Philosophical Society, Birmingham.
Deutscher wissenschaftlicher Verein, Santiago, Chili.

The following list gives the number of institutions, including societies, universities, government departments, libraries, museums, etc., to which, at the present date, our Transactions are sent, and from which publications are received in exchange :—

	Number of Institutions To which Transactions are sent:	Number of Institutions From which exchanges are rec'd:
Great Britain and Ireland	128	66
France	62	23
Germany	88	60
Russia	19	11
Austria-Hungary	23	11
Norway	13	11
Sweden	12	6
Belgium	14	4
Netherlands	9	4
Italy	34	18
Switzerland	15	8
Servia	1	0
Spain	2	0
Portugal	1	0
Denmark	5	2
India	9	3
China	3	0
Malta	1	0
Mauritius	1	0
Straits Settlements	0	1
Japan	2	1
South Africa	2	2
Australasia	36	22
Brazil	3	1
Chili	2	2
Argentina	4	4
Uruguay	1	1
British Guiana	1	1
Central America	2	4
Mexico	4	5
West Indies	4	1
United States	166	106
Newfoundland	1	0
Canada (exclusive of Nova Scotia .....44 Nova Scotia.....22	66	37
Totals	734	415

As pointed out in former reports, the Council distributes the publications of the Institute very liberally, sending them to many libraries, museums, etc., which issue no publications which they can send in return, and even to a considerable number of societies which do issue publications but have neglected hitherto to put the Institute on their exchange lists. Owing to the great courtesy of the Smithsonian Institution in granting to the Institute the privileges of its International Bureau of Exchanges, it costs very little more to be liberal than to be niggardly in distribution, and the Council regards liberality as the better policy both from the point of view of making the work of its members

known and from the point of view of spreading abroad a knowledge of the natural resources of the Province.

During the past year it has been found possible to bind about 120 volumes, all in the English tongue except a few foreign publications which were in considerable demand.

The library has increased so rapidly that it has been found necessary to remove from the Post Office building all except publications from Great Britain and Ireland and the United States. The balance of the Library can still be accommodated in the room at Dalhousie College, placed at the disposal of the Institute by the courtesy of the Board of Governors. But the day is not far distant when both the cases at the post office and the room at the College will hold no more, and it will be necessary, therefore, at an early date, to find some adequate local habitation for our books.

The library has been used more frequently during the past year than usual both by town and country members; but the lack of a catalogue, difficulty of access to the books owing to the lack of a paid librarian, and the inconvenience of the present location of the library, render it largely inaccessible to members.

On motion, the thanks of the Institute were conveyed to MR. M. BOWMAN, the Librarian, and to the Corresponding Secretary, PROF. J. G. MACGREGOR, for their efforts to build up the library.

The following were duly elected officers for the ensuing year (1895-6):—

President—E. GILPIN, JR., ESQ., LL. D., F. G. S., F. R. S. C.

Vice-Presidents—ALEXANDER MCKAY, ESQ., and A. H. MACKAY, ESQ., LL. D., F. R. S. C.

Treasurer—W. C. SILVER, ESQ.

Corresponding Secretary—PROF. J. G. MACGREGOR, D. SC., F. R. SS. C. & E.

Recording Secretary—HARRY PIERS, ESQ.

Librarian—MAYNARD BOWMAN, ESQ., B. A.

Councillors without office—MARTIN MURPHY, ESQ., D. SC.; WATSON L. BISHOP, ESQ.; WILLIAM MCKERRON, ESQ.; JOHN SOMERS, ESQ., M. D.; F. W. W. DOANE, ESQ., C. E.; RODERICK MCCOLL, ESQ., C. E.; S. A. MORTON, ESQ., M. A.

On motion, it was resolved that the thanks of the Institute be conveyed to the HON. R. BOAK, President of the Legislative Council, for his courtesy in permitting the use of the Council Chamber for the meetings of the Institute.

A vote of thanks was also presented to MR. A. McKAY for the able manner in which he had performed the duties of chairman.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 18th November, 1895.

The PRESIDENT in the chair.

Communications were read from the Physical-economic Society of Königsberg and from the Imperial German Academy of Halle, announcing the death of their Presidents; and likewise from the Geological Institute of Mexico, intimating the decease of its late Director.

DR. SOMERS then read a paper on "A Variation in the Plumage of the Canadian Ruffed Grouse or Birch Partridge *(Bonasa umbellus togata)*," describing a specimen which had been purchased in Halifax.

The subject was discussed by MESSRS. PIERS and BISHOP, who mentioned similar cases which had come under their observation.

MR. W. L. BISHOP exhibited an Albino Junco *(J. hyemalis)* which had been shot in May, 1887.

SECOND ORDINARY MEETING.

Legislative Council Chamber, Halifax, 9th December, 1895.

The PRESIDENT in the chair.

PROF. J. G. MACGREGOR presented a paper "On the Conductivity of Mixtures of Electrolytes." (See Transactions, p. 101).

Third Ordinary Meeting.

City Council Chamber, City Hall, Halifax, 13th January, 1896.

The President in the chair.

A paper by Prof. A. E. Coldwell, entitled : "Notes on the Superficial Geology of Kings County, N. S.," was read by the Corresponding Secretary. (See Transactions, p. 171).

The paper was discussed by Drs. Murphy and Gilpin, and Messrs. Black, Hemeon, McKay and Bishop.

Prof. J. G. MacGregor read a "Note on Newton's Third Law of Motion."—In former papers (Trans. Roy. Soc. Can., vol. x, sec iii, p. 3, (1892) and *Phil. Mag.* ser. 5, vol. xxxvi, (1893), p. 244) he had endeavoured to show that the attempt supposed by some writers to have been made by Newton and actually made by Maxwell and Lodge, to deduce the third of Newton's Laws of Motion from the first, was unsuccessful, the reasoning by which the deduction was made being fallacious. In the present paper attention was directed to the attempt made by Mr. R. T. Glazebrook, F. R. S., in his Elementary Text Book of Dynamics (Cambridge University Press, 1895, p. 151) to re-state the deduction in a new form, the object of the paper being to show that Glazebrook's deduction involved the same fallacy as those of Maxwell and Lodge.

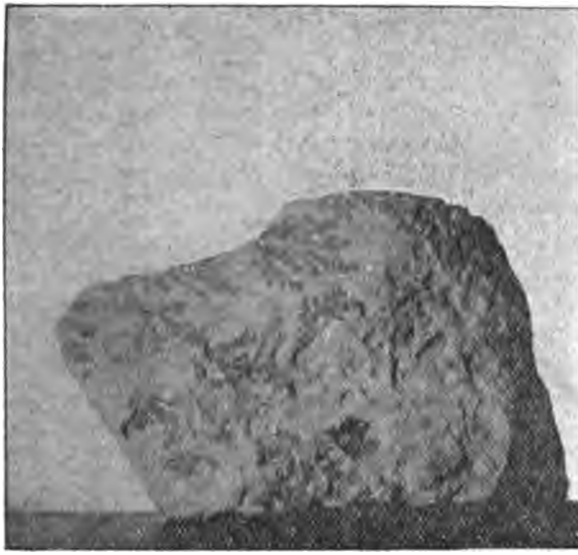
Fourth Ordinary Meeting.

City Council Chamber, Halifax, 10th February, 1896.

The President in the chair.

Dr. A. H. MacKay presented for examination by the members of the Institute, a flag of reddish freestone five times the linear dimensions of the reduced photographic representation given below, and bearing on one face a number of very distinct and beautiful dendritic markings representing very closely in general outline the figures and color of some of the finely sprayed, red seaweeds for which they were popularly taken. But, by the ordinary blowpipe tests, the simulated fronds of the red alga turned out to be an oxide of manganese instead of a fossil, and

the microscope demonstrated the entire absence of organic structure. The specimen came from the neighborhood of St. Mary's Bay, Digby



MANGANESE DENDRITES ON RED SANDSTONE.
(Reduced to one-fifth of linear dimensions.)

county. The structure of the flag showed that these Manganese dendrites were originally formed between two close layers of the original flaggy sandstone. He suggested as an explanation of the dendritic form of the manganese deposit, the observed fact that when a thin sheet of liquid holds in solution certain substances, and from any cause the solution is becoming supersaturated, these substances, if they have a tendency to crystalize, are not precipitated uniformly like ordinary sediment. The precipitation commences at a point where the supersaturation begins to develope, which, let it be supposed, in the thin plane of cleavage in the flag, was near the outer margin where the deposit salt first made its appearance. Assuming the crystaline attractive force to operate effectively at a distance of, say, the eighth of an inch, the precipitating material would congregate from that distance to the first point of deposition, leaving a clear space of that extent on each side. And as the supersaturation extended inwards, the point would be extended into a line. But, assuming that the wave of supersaturation

proceeds inward with a semi-circular, elliptical or other proximate form of a curve, a radiating system of lines would be required to spring up whenever the divergence between two lines of precipitation exceeded twice the effective attractive distance of the aggregations of deposits. Thus there would result a radiating, spray-like deposit, the branches budding forth at points necessary to allow of the precipitation of all material within the range of the specific attracting force. It will be seen that the branching of each of these figures practically fills up its particular basin so as to accommodate the precipitating molecules within a proximately constant distance.

He illustrated the same, or a similar principle, by enclosing between sets of two microscope glass slides, solutions of a variety of chemical salts, clipping the sides firmly together, and allowing the water to evaporate from the open margins all around. In many of these the salts were precipitated in more or less aborescent and vine-like forms starting from the open margin. Under the polariscope these forms were exhibited to those present, the various plays of color making the exhibition of popular interest.

The President, Dr. Gilpin, then read a paper on the "Undeveloped Coal Fields of Nova Scotia." (See Transactions, p. 134).

Remarks upon the subject were made by Mr. Dick, M. E.

Fifth Ordinary Meeting.

Legislative Council Chamber, Halifax, 9th March, 1896.

The President in the chair.

The Secretary was instructed to convey to His Worship the Mayor, the thanks of the Institute for the use of the City Council Chamber for recent meetings of the Society.

A paper by Prof. L. W. Bailey, Ph. D., entitled, "Some Illustrations of Dynamical Geology in South-Western Nova Scotia," was read by the Corresponding Secretary. It was illustrated by a number of photographs. (See Transactions, p. 180).

The paper was discussed by Drs. Murphy, MacKay, and Gilpin, Principal Trefry, and others.

Sixth Ordinary Meeting.

Legislative Council Chamber, Halifax, 13th April, 1896.

The President in the chair.

Harry Piers, Esq., read a paper entitled, "Preliminary Notes on the Orthoptera of Nova Scotia," illustrated by a collection of the insects described. (See Transactions).

The paper was discussed by Drs. Somers and MacKay, and Mr. Miller.

Dr. A. H. MacKay presented a desiccated specimen of *Diadophis punctatus* (L.), the Ring-necked or King Snake of Nova Scotia, for examination by the members present. The specimen was captured alive during the previous fall, at Pine Hill, near the Park, and was presented to him by the Rev. Dr. Gordon. Its habits in captivity were described, the principal one (not referred to in the other papers read before the Institute) being its ability, after moistening its ventral plates by passing through water, of climbing up the more than vertical walls of a tall glass beaker in which it was kept. As the mouth of this large beaker was covered with a sheet of thin cotton cloth clamped around its mouth by a rubber band, the snake used to climb up to the top and take a circular position around the mouth and as close to the band as possible. For a couple of months it was presented with quite a variety of things to eat and drink, but was never observed to take advantage of what was offered, except to go gliding through the water or other liquid supplied. Being neglected for a week or more towards the beginning of winter, it was found dead and desiccated one day, when the experiments came to a close. It agreed closely with the specimen described in detail by Mr. Harry Piers on the 14th March, 1892. (See Vol. viii., page 181, Trans. N. S. Inst. Sci.).

He then described an exciting frog hunt by one of three large Garter Snakes, *(Eutainia sirtalis)*—two of them having been killed to give the frog a better chance—which he had the good fortune to see on the partially dry bed of a rivulet near the Nictaux river in Annapolis county. The cunning and persistent determination shown by the snake in this case was most remarkable, whether in swimming and diving in the clear gravel-bottomed pool, or in climbing the rock and the bank.

The infatuation of the frog—a fine large Green Frog, *(Rana clamata)* it appeared to be—was shown by its always retreating to the water where it remained until closely pursued, when it sprang out in a leap or two to one side where it remained unconscious of any other presence, but very sensitive to the insidious approach of the snake who was so interested in its game that the presence of the slaughterer of its two colleagues was, apparently, a matter of no consequence. Owing to a mistaken observation that the frog had finally escaped and that the hunt was over, the snake was killed, when it was discovered that it was still stalking the frog and would have caught him or have forced him again into the pool. As the hunt continued for several minutes, a great many manœuvres by land and water were observed. He referred to notes made on the habits of the same species as described in the Transactions of the Institute, Vol. I, part 2, page 120, by J. M. Jones, May 2nd, 1865; Vol. IV, page 81, by J. Bernard Gilpin, April, 1875; and Vol. IV, page 163, by John T. Mellish, May, 1876.

After discussing the distribution of the Reptillia in the Atlantic Provinces, he gave the appended list which briefly shows all the species known on good authority to be found within the Province of Nova Scotia.

He next presented a living specimen of the Newt, *(Diemyctylus viridescens)*, which was examined by the members, swimming in water and moving on the table. It was one of a pair which had come the spring before from a lake in the county of Lunenburg, and the habits of which he had been studying for a year. The other, having been taken for some time with an apparent longing for the wide world beyond the horizon of its tank, which for some days before it was pensively gazing at from an island rock, must have made a leap or unusual reach, and escaped never to be seen again. He gave an outline of its history from the minute eggs deposited in spring on small leaves of water plants; of its growth in the water, until in August or September it gradually changed into a red land salamander, left the water and hunted like a terrestrial animal, with air breathing apparatus and even a ciliated epithelial lining to its air passages. Until lately this stage used to be considered to be a species of salamander. Then, when mature, the "crimson eft" betakes itself to the water, changes its color to an olive green with a row of minute black-bordered vermilion spots on each side of its back. Its breathing apparatus again becomes adapted to the water, even the ciliated epithelia disappearing. The

specimen was for a year in this speckled olive-green stage, when it is essentially a water animal, although it is capable of living out of the water, and sometimes appears to take pleasure in basking high and dry. Its peculiar and very decided amphibious nature made it even more interesting from a biological point of view than any of its congeners among our batrachians. He described its manner of catching a struggling fly when thrown on the surface of the water, while a dead or motionless fly would not be touched; its swallowing of small fibres of fresh meat when hungry, when it might be fed from a splinter of wood to which the fibres were made to adhere. He referred to the description of a specimen by Harry Piers, before the Institute, 14th March, 1892, as given in the Transactions of the Institute, Vol. VIII, page 183.

He then discussed the distribution of the other batrachian relatives of the Newt in the Atlantic Provinces, and gave the following list as the species known to belong to the Province, on good authority. In the museum of the Pictou Academy there were specimens of all the reptilia and batrachia of the list except the Wood Tortoise, which was given on the authority of Mr. Jones, in a paper already referred to.

BATRACHIA AND REPTILIA OF NOVA SCOTIA.

[*Nomenclature of Jordan's Manual of the Invertebrates, 1888.*]

Class—BATRACHIANS.

Order—*Salamanders.*

1. Amblystoma punctatum (L). (Yellow-spotted Salamander).
2. Plethodon erythronotus (Green). (Red-backed Salamander).
3. ? (Blackish sp.)

Order—*Newts.*

3. Diemyctylus viridescens (Raf). (Red Eft, or Vermillion-spotted Olive-Back Newt).

Order—*Toads and Frogs.*

4. Bufo lentiginosus (Shaw). (American Toad).
5. Hyla versicolor (Le Conte). (Common Tree Toad).
6. Hyla Pickeringii (Holbrook). (Pickering's Tree Toad).
7. Rana virescens (Kalm). (Leopard Frog).
8. Rana sylvatica (Le Conte). (Wood Frog).
9. Rana clamata (Daudin). (Green Frog).
10. Rana Catesbiana (Shaw). (Bull-Frog).

Class—REPTILES.

Order—*Serpents.*

1. Storeria occipitomaculata (Stor). (Red-Bellied Snake).
2. Eutainia sirtalis (L). (Common Garter Snake)
3. Liopeltis vernalis (DeKay). (Grass Snake).
4. Bascanion constrictor (L). (Black Snake).
5. Diadophis punctatus (L). (Ring-necked Snake).

Order—*Turtles.*

6. Dermochelys coriacea (Vandelli). (Leather Turtle).
7. Chelydra serpentina (L). (Snapping Turtle).
8. Chrysemys picta (Hermann). (Painted Turtle).
9. Chelopus insculptus (Le Conte). (Wood Tortoise).

DR. MACKAY's communication was discussed by MR. PIERS, DR. SOMERS, and MR. MILLER.

A paper, "On the Calculation of the Conductivity of Mixtures of Aqueous Solutions of Electrolytes having a common Ion," by D. McINTOSH, ESQ., Dalhousie College, was read by title.

Notice of the May meeting of the Royal Society of Canada was read. The PRESIDENT of the Institute was appointed delegate to the meeting, with power to appoint a substitute if necessary.

SPECIAL MEETING.

Legislative Council Chamber, Halifax, 27th April, 1896.

The PRESIDENT in the Chair.

REV. G. PATTERSON, D. D., LL. D., of New Glasgow, N. S., having been invited by the Council to address the Institute on his investigations in relation to the Folk-speech of Newfoundland, in order that the attention of members of the Institute might be directed to this kind of research, read the following paper:—

NOTES ON THE DIALECT OF THE PEOPLE OF NEWFOUNDLAND.

Of late years Folk-lore, by which is meant popular superstitions, tales, traditions and legends, has engaged a large amount of attention, and is now universally recognized as of great value in the study of anthropology and comparative religion. Closely connected with this is the study of folk-speech, or the words and linguistic forms of the common people, as distinguished from the literary language of the cultured classes. These, though the consideration of them may be regarded as more properly belonging to the science of philology, are yet also of interest as connected with the history and migrations, the beliefs and modes of life of the peoples among whom they are found.

Hitherto, in Nova Scotia, attention has scarcely been directed to either of these subjects. I know of no systematic attempt either to gather up the folk-lore or to discuss the linguistic peculiarities of our people. And yet we have an ample field. Our original settlers were principally French, German, English, Irish, Lowland Scotch, and Celtic,

with some intermixture of North American Indians and Africans, and other elements in less proportion. These all brought with them various folk-tales, legends and superstitions, and as these different races remain in a large measure distinct, they retain them to a good degree still. As they mix with other races and become more educated, they may lose them, but often the intermixture tends to their wider extension. In the same way there arises an interchange of words and phrases, which form dialectic peculiarities more or less widely spread according to circumstances.

Recently my attention was directed to the folk-lore and folk-speech of Newfoundland. I had not more than begun to mingle with her people till I observed them using words in a sense different from what I had ever heard elsewhere. This was the case to some extent in the speech of the educated, in their law proceedings and in the public press, but was of course more marked among the uneducated. Among the latter particularly I found, in addition, words in use which were entirely new to me. Further intercourse convinced me that these peculiarities presented an interesting subject of study, and after some enquiry I prepared two papers, the first of which was read before the Montreal branch of the American Folk-lore Society, and published in the American Folk-lore Journal for January-March, 1895, and the other was read before that society at their late meeting and published in the same journal. It has been thought desirable that the results of my enquiries should be brought under the notice of Nova Scotian students, and I have therefore consented to condense my two papers into one adding such additional information as I have since received and to present it before the Institute of Science.

It may seem strange that I should have directed such particular attention to the dialectic forms of Newfoundland, where I was quite a stranger, while there remains a similar field in Nova Scotia quite uncultivated. But it was just because I was a stranger that my ear at once caught the sound of unusual words, or of words used in unusual senses, and I was led to these investigations. Equally interesting forms of speech are perhaps to be found in Nova Scotia, but they await the investigations perhaps of some stranger who may come to sojourn among us.

In explanation of the origin of these peculiarities it is to be kept in view that the most of the original settlers of Newfoundland came either

from Ireland or the west of England. In consequence the present generation very generally speak with an Irish accent, and some words or phrases will be found in use of Irish origin. Their coasts too, having been from a very early period frequented by fishermen of all nations, and their trade bringing them in contact with people of other tongues, we might expect foreign words to be introduced into their speech. The accessions to their vocabulary from these sources, however, are few, and their language remains almost entirely English. Even the peculiarities which strike a stranger, are often survivals of old forms which are wholly or partially obsolete elsewhere.*

I. I notice words which are genuinely English, but are now obsolete elsewhere or are only locally used :—

An atomy or *a natomy*. a skeleton, applied to a person or creature extremely emaciated. "Poor John is reduced to *an atomy*." This is a contraction of the word anatomy, probably from a mistake of persons supposing the *a* or *an* to be the article. This use agrees with the original meaning of the word, which was not the act of dissecting, but the object or body to be dissected, and hence as the flesh was removed, the skeleton, a word which then denoted a *dried* body or mummy. (Greek, *skello*, to dry.)

> Oh tell me, friar, tell me
> In what part of this vile *anatomy*
> Doth my name lodge? Tell me that I may sack
> The hateful mansion.
>
> —Shakspeare, *Romeo and Juliet*, III, 3.

Hence it came to denote a person extremely emaciated.

> They brought one Pinch, a hungry lean-faced villain,
> A mere *anatomy*,
> A living dead man. —*Comedy of Errors*, V, 1.

Shakspeare also used the abridged form *atomy* in the same sense, which is exactly the Newfoundland meaning of the word.

> "Thou starved bloodhound . . . thou *atomy*, thou."
>
> —*2 Henry IV*, V, 4.

The same is given by Jamieson† as in use in Lowland Scotch.

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* In these investigations I must especially acknowledge the assistance received from Judge Bennett of Harbor Grace, Newfoundland, who has not only furnished me with a number of words, but has carefully examined the whole list. I have also to acknowledge my obligations to an article by the Rev. Dr. Pilot of St. Johns, published in *Christmas Bells*, a paper issued in that city at Christmas. A few additional facts have been received from Mr. W. C. Earl, of the Western Union Telegraph Company, and others. For most of the quotations I am indebted to the *Encyclopædic* Dictionary.

† Scottish Dictionary.

Barvel, sometimes pronounced *barbel*, a tanned sheepskin used by fishermen, and also by splitters, as an apron to keep the legs dry, but since oilskin clothes have come into use, not now generally employed. Wright in his "Dictionary of Obsolete and Provincial English," marks it as Kentish, denoting "a short leather apron worn by washerwomen or a slabbering bib." Recently I heard of its being used by a fisherman on our Nova Scotia coast, to describe the boot or apron of a sleigh or carriage.

Barm is still commonly, if not exclusively used in Newfoundland for *yeast*, as it is in some parts of England. So *billets*, for small sticks of wood has now, with most English-speaking people, gone out of use. But it is quite usual in Newfoundland to hear of buying or selling *billets*, putting in *billets*, &c. The word, however, seems to have been introduced from the Norman French.

Brews.—This is a dish, which occupies almost the same place at a Newfoundlander's breakfast table, that baked beans are supposed to do on that of a Bostonian. It consists of pieces of hard biscuit, soaked over night, warmed in the morning, and then eaten with boiled codfish and butter. This is plainly the old English word usually written *brewis*, and variously explained. Johnson defines it as "a piece of bread soaked in boiling fat pottage made of salted meat." This is about the Newfoundland sense, substituting, as was natural, fish for meat. Webster gives it as from the Anglo-Saxon, and represents it as obsolete in the sense of broth or pottage, "What an ocean of *brewis* shall I swim in," (Beaumont & Fletcher), but as still used to denote "bread soaked in gravy or prepared in water and butter." This is the relative New England dish. Wright gives it in various forms *brewet*, *brewis*, &c., as denoting pottage, but says that in the North of England they still have "a *brewis*, made of slices of bread with fat broth poured over them."

Child is used to denote a female child. This is probably going out of use, as gentlemen, who have resided for some time on the island, say they have never heard it, but I am assured by others, that on the occasion of a birth they have heard at once the enquiry, "Is it a boy or a child?" Wright gives it as Devonshire, and it was in use in Shakspeare's time, "Winter's Tale," III, 3, "A boy or a childe, I wonder." In two instances I have heard of its being used in this sense some years ago in Nova Scotia. The one was by an old man originally from the United States, who used Shakspeare's enquiry "A boy or a child." Again in a

town settled by New Englanders I am informed by one brought up in it, that when he was a boy some forty years ago, it was a favorite piece of badinage with young people to address a young husband on the birth of his first-born, "Is it a boy or a child?" They did not know the meaning of the phrase, but used it in the way of jeering at his simplicity, as if he had not yet been able to decide the question. This is an example of the manner in which words or phrases, after losing their original meaning, still continue to be used and receive a different sense.

Clavy is used to denote a shelf over the mantelpice. Wright, (Dictionary of Obsolete and Provincial English,) gives it as denoting the mantelpiece itself, and thus it is still used in architecture. Halliwell, (Dictionary of Archaisms,) gives *clavel*, *clavy*, and *clavel piece* with the same meaning, and *clavel tack*, which he supposes means the shelf over the mantelpiece, the same as the *clavy* of the Newfoundlanders. In French we have *claveau*, the centrepiece of an arch.

Clean is universally used in the sense of completely, as frequently in the Authorized Version of the Scriptures (Ps. lxxvii. 8; 2 Pet. ii. 18, etc.), and as still in Scotch. "He is *clean* gone off his head." "I am *clean* used up." The word *clear* is sometimes used in the same sense.

Conkerbills, icicles formed on the eaves of houses, and the noses of animals. Halliwell gives it in the form of *conkabell*, as Devonshire for an icicle.

Costive, costly. "That bridge is a *costive* affair." I had at first supposed this simply the mistake of an ignorant person, but in a tale written in the Norfolk dialect I have seen *costyve* given in this sense, and I am informed that it is used in the same way in other counties of England, and sometimes if not generally pronounced *costeev*.

Dodtrel, an old fool in his dotage, or indeed a silly person of any age. It is usually spelled *dotterel*, and primarily denoted a bird, a species of plover. From its assumed stupidity, it being alleged to be so fond of imitation that it suffers itself to be caught while intent on mimicking the actions of the fowler, the term came to denote a silly fellow or a dupe.

> Our *dotterel* then is caught,
> He is, and just
> As dotterels used to be; the lady first
> Advanced toward him, stretched forth her wing, and he
> Met her with all expressions —*Old Couplet*, iii.

Dout, a contraction of "do out," to extinguish, and *douter*, an extinguisher, marked in the dictionaries as obsolete, but noted by Halliwell as still used in various provincial dialects of England.

> First, in the intellect it *douts* the light.—Sylvester.
>
> The dram of base
> Doth all the noblest substance *dout*.
>
> Shakespeare, *Hamlet* i. 4.

Newfoundlanders also express the same idea by the phrase, "*make out* the light."

Droke, a sloping valley between two hills. When wood extends across it, it is called a *droke* of wood. In Old Norse there is a noun *drög*, a streak, also a noun *drag*, a soft slope or valley, which in another form *drog*, is applied to the watercourse down a valley. Similar is the word *drock*, in Provincial English given in Halliwell as in Wiltshire a noun meaning a watercourse, and in Gloucester a verb, to drain with underground stone trenches.

Drung, a narrow lane. Wright and Halliwell give it under the form of *drun*, as Wiltshire, with the same signification.

Dunch cake or bread, unleavened bread, composed of flour mixed with water and baked at once. So Wright and Halliwell give *dunch dumpling* as in Westmoreland denoting "a plain pudding made of flour and water."

Dwoll, a state between sleeping and waking, a dozing. A man will say, "I got no sleep last night, I had only a *dwoll*." This seems kindred to the Scotch word *dwam*, which means swoon. "He is no deid, he is only in a dwam." Wright and Halliwell give a similar if not the same word as *dwale*, originally meaning the plant nightshade, then a lethargic disease or a sleeping potion.

Flankers, sparks coming from a chimney, so Halliwell gives it as meaning sparks of fire. In old English, when used as a verb, it denotes to sparkle.

> "Who can bide the *flanckering* flame
> That still itself betrays?"
>
> —Turbevile's *Ovid*, p. 83.

The noun is generally *flanke* or *flaunke* (Dan. flunke) a spark.

> "Felle *flaunkes* of fyr and flashes of soufre."
>
> —Early Eng. Allit. Poems, "*Cleanness*," 953.

Flaw, a strong and sudden gust of wind, Norwegian *flage* or *flaag*. The word is used by Shakspeare and Milton :

> Should patch a wall to expel the winter's *flaw*.—*Hamlet.*
> And snow and hail and stormy gust and *flaw*.—*Paradise Lost.*

And also by Tennyson :

> "Like *flaws* in summer laying lusty corn."

It is still in use among English seamen.

Foreright, an old English word used both as an adjective or an adverb to denote right onward.

> "Their sails spread forth and with a *foreright* gale."
> —Massinger, *Renegade, V.*
>
> "Though he *foreright*
> Both by their houses and their persons passed."
> —Chapman, *Homer's Odyssey, VII.*

Hence it came to mean obstinate or headstrong. In Newfoundland it means foolhardy.

Frore, for froze or frozen. This is used by Milton :

> "The parching air
> Burns *frore* and cold performs the effect of fire."

Glutch, to swallow. "My throat is so sore that I cannot *glutch* any thing." Wright and Halliwell give it as old English, in the same sense.

Gossip, originally *Godsib*, from *God* and *sib*, meaning kin or relationship by religious obligation, is still quite commonly used in Newfoundland to denote a god-parent. *Sib*, which in old English and Scotch denotes a relative by consanguinity, is used there exclusively to denote relationship formed by sponsorship.

Groaning cake. When a birth is expected, a cake is prepared called the *groaning cake.* Very soon after it occurs, with little regard to the feelings or nerves of the mother, a feast is made, particularly for the elderly women, of whom all in the neighbourhood are present. This is called the "*bide-in* feast," and at it the "groaning cake" is distributed,—bearing the same relation to the occasion that "bride-cake" does to a marriage feast. This is in accordance with the old English practice and language, in which, according to Halliwell, *groaning* denotes lying-in. Heuce we have in Scotch *groaning malt*—drink provided for the occasion, and in old English *groaning cheese*, *groaning chair* and *groaning cake.* Judge Bennett supposes that the name of

the feast is only the present participle of *bide*, and means staying or waiting.

Gulch. The dictionaries give this word as an obsolete word, which means to swallow ravenously, and Wright gives it as Westmoreland for to swallow. In this sense it is used at Spaniard's Bay, and probably at other places on the coast of Newfoundland. As a noun it is used in other parts of America as denoting a ravine or small hollow. It is also applied to those hollows made by vehicles in snow roads known in Canada as *pitches*. But as a verb, it has come on the Labrador coast, to have a meaning peculiar to that region and to those who frequent it. In summer men, women and children from Newfoundland spend some weeks at the fishing there, living in a very promiscuous way. As there is no tree for shelter for hundreds of miles of islands and shores, parties resort to the hollows for secret indulgence. Hence gulching has, among them, become a synonym for living a wanton life.

Gurry, the offal of codfish, now obsolete, but by a euphuism represented in dictionaries as meaning "an alvine evacuation."

Hackle is used in two senses, and for two English words. The one is to cut in small notches, as to "hackle" the edge of the door. This is the same as the word to *hack*, defined "to cut irregularly, to notch with an imperfect instrument or in an unskilful manner." The other denotes the separating the course part of the flax from the fine, by passing it through the teeth of an instrument called in Northumberland and Yorkshire, a *hackle*, in Scotch, a *heckle*. Hence the word came to mean to handle roughly or to worry, particularly by annoying questions. In Newfoundland *hackle* and *cross-hackle* are specially applied to the questioning of a witness by a lawyer, when carried to a worrying degree.

Haps, to hasp or fasten a door. This was the original Anglo-Saxon form *hapse* or *haps*. It is defined by Johnson as a noun, a clasp folded over a staple and fastened on with a padlock, and as a verb, to fasten in this manner. Wright gives it as Berkshire for to fasten, and Devonshire for the lower part of a half door. In Newfoundland it denotes to fasten in general.

Hat, a quantity, a bunch or a heap. A hat of trees means a clump of trees. According to Jamieson, in some parts of Scotland the word means a small heap of any kind carelessly thrown together.

Helve is the term universally used for an axe handle, and as a verb it denotes putting a handle to that implement.

Heft as a verb, to raise up, but especially to prove or try the weight of a thing by raising it, is marked in dictionaries as Provincial English and Colloquial United States, but it is still used in the same sense in Newfoundland. Thus one returning home with a good basket of fish may say to a friend "heft that,"—feel the weight of it. And so as a noun it is used with the relative meaning of weight.

Houseplace, the kitchen. In old English, according to Wright, it meant the hall, the first large room after entering the house. Halliwell explains it as denoting in a farm house, the kitchen or ordinary sitting room. It is still in ordinary use in Scotland.

Jonnick, in Newfoundland, means honest, but according to Wright, in the Northamptonshire dialect it means kind or hospitable.

Killock, an old English word used to denote a small anchor, partly of stone and partly of wood, still used by fishermen, but going out of use in favor of iron grapnels.

Kilter, regular order or condition, "out of kilter," disordered or disarranged. It is common in old English, but generally spelled *kelter*. Thus Barrow says, "If the organs of prayer be *out of kelter*, or out of tune, how can we pray?" Under the spelling "kilter," it is common in New England.

Knap, a knoll or protuberance above surrounding land. It appears in Anglo-Saxon as *knappe*, and in kindred languages as denoting a knob or button, but in old English it denotes "the top of a hill or a rising ground" (Wright).

Leary, hungry, faint. This is the old English word *lear* or *leer*, in German *leer*, signifying empty or hollow, having its kindred noun *lereness*.

> "But at the first encounter downe he lay,
> The horse runs *leere* without the man."
> —Harrington's Ariosto, XXXV. 64.

Linney, a small building erected against a bank or another building. In New England it is generally pronounced *linter*, or *lenter*. This is commonly regerded as a corruption of *lean to*. But Wright gives *linhay* as in the Westmoreland dialect denoting an open shed. In this form, also it appears in "Lorna Doone," a novel written in the Devonshire dialect.

Liveyer. This word is used particularly on the coast of Labrador, but also in Newfoundland, to denote a resident, in contrast with one visiting for fishing or other purposes. It simply seems the word *liver*, altered in the pronunciation. They treat the word *lover* in a similar way, calling it *loveyer*, as is done in some English provincial dialects. This, however, being from the Anglo-Saxon *lufian*, is nearer the original than the common form.

Logy, heavy and dull in respect of motion. Anglo-Saxon *liggan*, Dutch *logge*, a sluggard. In the United States the word is applied to men or animals, as a *logy* preacher or a *logy* horse. In Newfoundland, in like manner, they will speak of a *logy* vessel, a slow sailer, and in addition, when from want of wind a boat or vessel cannot get ahead or can only proceed slowly, they will speak of having a *logy* time.

Lun, a calm. This word exists in Scotch and northern English as *loun*. It also appears in Swedish as *lugn*, pronounced *lungn*, and in old Icelandic as *logn*, pronounced *loan*.

Marebrowed. The word *mare* in Anglo-Saxon means a demon or goblin, of which we have a survival in the word *nightmare*. But there is in Newfoundland another survival of it in the word *mare browed*, applied to a man whose eyebrows extend across his forehead, and who is dreaded as possessed of supernatural powers.

Midered or *moidered*, worried. In the latter form Halliwell gives it as provincial English for distracted.

Mouch, to play truant, and also applied to shirking work or duty. This is the same with the old English word, variously spelled *meech*, *meach* and *miche*, to lie hid or skulk, hence to cower or to be servilely humble or mean. The form *mouch* is still retained in the north of Ireland and is common in Scotland. I lately observed it as used by the tramps in New York to denote concealing or disguising one's self. I find it also used by school boys in some parts of Nova Scotia.

Mundel, a stick with a flat end for stirring meal when boiling for porridge. Wright gives it as used in Leicestershire as an instrument for washing potatoes, and he and Halliwell both give it as Northumberland, denoting a slice or stick used in making puddings. In Old Norse there is a word *möndull*, pronounced *mundull*, which means a handle, especially of a handmill, and the word is frequent in modern Icelandic.

Nesh, tender and delicate, used to describe one who cannot stand much cold or hard work. This is old English, but marked in the dictionaries as obsolete except in the midland counties of England; Halliwell adds Northumberland.

He was too *neshe* and she too harde.—Gower *C. A. V.*

It may be noted here that the people of Newfoundland use the word *twinly* with almost the same meaning. It is undoubtedly formed from twin like *twinling*, a diminutive, meaning a little twin, given by Wright as *twindling*.

Nunch, the refreshment men take with them on going to the woods. It is an old form of the word "lunch" as "nuncheon" for "luncheon" (Wright). But by others it is regarded, we think not so probably, as referring to noon, and meaning the refreshments that laborers partake of at that hour. Connected with this is the word *nunny bag* originally meaning a lunch bag, but now used in the general sense of a bag to carry all the articles necessary in travelling. They have also a very expressive word, though I am not sure that it is general, *nunny fudger*, denoting primarily a man who is thinking more of his dinner than of his work, hence generally a man who looks out for his own interest.

Patienate, long suffering. Wright gives it as used in Westmoreland in the same sense.

Peek, to peep, common in New England.

Perney, an adverb meaning presently or directly, as when a servant told to go and do a thing might reply "I will *perney*." The word I do not find in any dictionary to which I have access, but from cognate words I believe that it has come down from the old English. Related to it is the Latin adjective *pernix*, quick, nimble, active, and the old English word *pernicious*, signifying quick. Thus Milton:—

Part incentive reed
Provide *pernicious* with one touch of fire.
Paradise Lost, vi. 520.

Hence the noun *pernicity*, swiftness of motion which lingered longer. "Endued with great swiftness or *pernicity*," Ray on the Creation, 1691.

Piddle or *peddle*, is used to describe dealing in a small way, without any reference to hawking or carrying goods round from house to house for sale. This was the old meaning of the word.

Pook, a hay cock. Wright gives it as in Westmoreland and Halliwell as in Somerset used in the same sense.

Prong, a hay or fish fork. This is the meaning given by Johnson, who does not mention it as denoting one tine of a fork. So Wright gives it as an old English word denoting a hay fork.

Putter along, an old English form still in use in New England for "potter," to walk languidly or to labor inefficiently.

Quism, a quaint saying or conundrum. In Anglo-Saxon from *cwethan* to say comes *cwiss* a saying.

The Newfoundlanders have also the word *quisitize*, to ask questions of one, but it seems to be of different origin.

Rampike, a dead spruce or pine tree still standing. It is used in the same sense by the woodsmen of the Maritime Provinces, and probably of New England. It is probably the same as the old English word *rampick*, an adjective, "applied to the bough of a tree, which has lesser branches standing out at its extremity," (Wright).

Ramshorn, a wooden pound for washing fish in. But Wright gives it as a Somerset word denoting a sort of net to enclose fish that come in with the tide. So Halliwell.

Randy is used both as a noun and a verb, of the amusement of coasting. "Give us a randy" or "the boys are randying." In Anglo-Saxon it means boisterous, and "on the randy" meant living in debauchery. The word is retained in Scotland, where it means a romp or frolic, but generally in an unfavorable sense.

Roke or *roak*, smoke or vapor (Anglo-Saxon, *reocan*, to smoke), the same as reek in old English and Scotch. Thus Shakespeare:

> "Her face doth *reek* and smoke."—*Venus and Adonis*, 555.

Still used poetically

> "Culloden shall *reek* with the blood of the brave."—*Campbell.*

Robustious, is an old English word used by Milton, the same in meaning as *robust*, originally used in a favorable sense, but coming to mean violent and unruly. Hence it became a term of reproach, and finally fell out of use. But the Newfoundlanders still use it, or the similar word *robustic*, in its original favorable signification.

Ructions. This word is used in Newfoundland to denote noisy quarrellings. I had supposed that it was Irish and a corruption of insur-

rections. But Halliwell gives it as Westmoreland for an uproar, so that it is probably old English.

Scred, a piece or fragment. It seems the same as "shred," the Anglo-Saxon *screade*. Webster gives Provincial English *screed*.

Seeming, judgment or opinion. Given in dictionaries as obsolete, but used by the best writers of the past. Thus Milton has

> The persuasive words impregnd
> With reason to her *seeming*.—*Paradise Lost*, ix. 738.

And Hooker says, "Nothing more clear to their *seeming*."

In Newfoundland, the sled or sleigh of the continent, the sledge of the English, is called a *slide*, but according to Wright this is the original form in old English. So *shard* is used as in Shakspeare's time and as still in some Provincial dialects of England to denote broken pieces of pottery.

Spancel, as a noun, denoting "a rope to tie a cows hind legs" and as a verb to "tie with a rope." In the dictionaries it is given as Provincial English and an English gentleman informs me that the word is still in common use in Yorkshire.

Spell from Anglo-Saxon *spelian* means in old English, as a verb, to supply the place of another, or to take a turn of work with him, and as a noun, the relief afforded by one taking the place of another at work for a time. In a similar sense it is used in Newfoundland. A Newfoundlander speaking of seals as swiles was asked how they spelled the word, replied, "We don't spell them, we generally haul them." It is however specially used to denote carrying on the back or shoulders. "He has just *spelled* a load of wood out," meaning he has carried it on his back. It is also applied to distance, as "How far did you carry that load," Answer, "Three shoulders *spells*," meaning as far as one could carry without resting more than three times. In connection with this I may note that the word *turn* is used to denote what a man can carry. "He went into the country for a *turn* of good," that is as much as he can carry on his back. The Standard Dictionary mentions it as having the same meaning locally in the United States.

Starve, viz., with cold or frost. I have heard the same in Nova Scotia. Johnson gives it as a verb neuter, with one of its meanings "to be killed with cold," and as active with the meaning to "kill with cold" and quotes Milton's line,

> From beds of raging fire to *starve* in ice.

Webster gives this meaning as common in England, but not in the United States, though he quotes W. Irving as writing "*starving* with cold as well as hunger."

Strouters, the outside piles of a wharf, which are larger and stronger than the inner ones which are called *shores*. According to Wright in the Somerset dialect it denotes anything that projects.

Swinge, a form of *singe*, pronounced obsolete, but preserved in various English Provincial dialects, is the only one heard here. It is an ancient if not the original form of the word. Thus Spencer says,

"The scorching flame sore *swinged* a l his face."

Till Tib's eve, an old English expression equivalent to the "Greek Kalends," meaning never, is found here. The origin of the phrase is disputed. The word *Tib* is said to have been a corruption of the proper name Tabitha. If so the name of that good woman has been sadly profaned, for it came to signify a prostitute

"Every coistrel
That comes inquiring for his *tib*."—Shakespeare, *Pericles*.

But St. Tib is supposed by some to be a corruption of St. Ubes, which again is said to be a corruption of Setubal. This, however, gives no explanation of the meaning of the phrase, and there is really no saint of the name. To me the natural explanation seems to be, that from the utter unlikelihood of such a woman being canonized, persons would naturally refer to her festival, as a time that would never come.

Tilt, a log house such as lumbermen use; a rough temporary shelter, like a shanty in Canada, only instead of being built of logs laid horizonally one on the other, it is usually composed of spruce or fir wood placed vertically, and covered with bark. In Anglo-Saxon it appears as *telt* and *telde*, from *telden*, to cover. According to the dictionaries from Johnson, it is used to denote a tent, an awning or canopy, as over a boat.

Troth plight, one espoused or affianced. So Shakespeare

This your son-in-law
Is *troth plight* to your daughter.—*Winter's Tale*.

Tussock, a bunch or tuft of grass. It is marked in the dictionaries as obsolete, but it is still in use in Newfoundland to denote the matted tufts of grass found on the bogs.

Yaffle, an armful, applied especially to gathering up the fish which have been spread out to dry, a small yaffle denoting as many as can be

held in the two hands, and a large yaffle, expressing what a man would encircle with his arms. The word is also used as a verb, meaning to gather them up in this manner. The Standard Dictionary gives it as used locally in the United States in this last sense. But the Newfoundlanders do not limit it to this. They will speak of a yaffle, *e. g.*, of crannocks. Wright and Halliwell give it as used in Cornwall as a noun denoting an armful.

Yarry, early, wide awake, as a yarry man or a yarry woman. Wright and Halliwell give this word spelled *yary* as Kentish, meaning sharp, quick, ready. They, however, give *yare* as another word, though almost if not quite identical in meaning. They are closely related, appearing in Anglo-Saxon as *gearu* or *gearo*, and in kindred languages in various forms. In old English *yare* is used as an adjective meaning ready.

This Tereus let make his ships *yare*.—Chaucer. *Legend of Philomene.*

It is applied to persons meaning ready, quick.

Be *yare* in thy preparation.— Shakespeare, *Twelfth Night*, iii. 4.

And as an adverb, meaning quickly.

Yare, yare, good Iris, quick.—Ibid., *Anthony and Cleopatra.*, v. 9.

It is well known that the word *girl* is not found in the Anglo-Saxon or other languages of the North of Europe, and that it only occurs in two places in the authorized English version of the bible, showing that at the time that version was made, it was only beginning to be introduced into England. In Newfoundland it is only where the people have been intermixed with persons from other quarters that it has come into use, and in more remote places it is perhaps not used yet, the word "maid" pronounced *m'yid* being generally employed instead.

The use of *to* as meaning this, as in to-day, to-night and to-morrow is continued in *to year*, this year and *to once* at once.

I may also notice that they use the old form *un* or *on* in the composition of words denoting the negative, where present usage has *in* or *im*. Thus they say unproper or onproper, undecent, unlegal, &c.

There are also the remains of old English usage in their use of the pronouns. Thus every object is regarded as either masculine or feminine, and is spoken of as either "he" or "she." "It" seems only to be used where it has been acquired by intercourse with others. A man speaking of his head will say "he aches." Entering the court house I heard a witness asked to describe a codtrap. He immediately replied,

"*He* was about seventy five fathoms long," &c. Other objects are spoken of as "she," not only boats and vessels, but a locomotive. Of this old usage we have a remnant in the universal use of the feminine for ships.

Another old form still common is the use of the singular *thee* and *thou*, where now the plural *you* is commonly employed. With this is joined what is still common in parts of England, the use of the nominative for the objective, and to some extent the reverse.

Some peculiarities may be noticed also in the formation of the past tense of verbs. Thus the present *save* becomes in the past *sove*, and *dive* in like manner *dove*. But the very general usage is to follow the old English practice of adding "ed." Thus they say *runned* for ran, *sid* for saw, *hurted* for hurt, *falled* for fell, *comed* for came, even *sen'd* for sent, and *goed* for went. This last however is true English, retained in Scotland in *gaed*, while *went* does not belong to the verb at all, but is the past of another verb to *wend*. More curious still is the use of *doned* for did or done. Perhaps however this is not common.

The use of the letter "*a*" as a prefix to participles or participial nouns to express on action still going on, is still retained, as a-walking, a-hunting, etc.

Again in some places there is retained in some words the sound of *e* at the end where it is now omitted in English. Thus "hand" and "hands" are pronounced as if written "hande" and "handes." This is old English. We find it in Coverdale's version of the Bible, Tyndale's New Testament, which however sometimes has "honde" and "hondes," and Cranmers.

A number of words written with *ay* and with most English speaking having the long sound of *a*, are in Newfoundland sounded as if written with a *g*. Thus they say w'y, aw'y, pr'y, pr'yer, b'y, for away, pray, prayer, bay. So n'yebors for neighbors. This pronunciation is still retained in Scotland, and R. Lowell refers to it as in Chaucer, and quotes it as an example of the *lastingness* of linguistic peculiarities.

In their names of objects of natural history we find the retention of a number of old English words. Thus whortleberries or blueberries are called *hurts*, nearly the same as the old English whurts or whorts, marked in the dictionaries as obsolete. Then they call a flea a *lop*, the Anglo-Saxon *loppe* from *lope* to leap, and wasps they call *waps*, which is the same with the Anglo-Saxon *waps* and the low German wepsk. A

large vicious fly is called a *stout*, but according to Wright and Halliwell this is the Westmoreland name for the gadfly. Then the snipe is called a *snite*, which is the old English form, "The witless woodcock and his neighbor *snite*." (Drayton's "Owl.") Earthworms are termed *yesses*, which Wright gives as Dorset-shire and Halliwell as Somerset.

II. I have next to notice words still in general use, but employed by Newfoundlanders in a peculiar sense, this being sometimes the original or primary signification.

Perhaps in this respect the stranger is most frequently struck by the use of the woids *plant* and *planter*. Neither has any reference to culti vating the soil. A planter is a man who undertakes fishing on his own account, a sort of middleman between the merchants and the fishermen. He owns or charters a vessel, receive all the supplies from the merchants, hires the men, deals with them, superintends the fishing, and on his return deals wfth the merchants for the fruits of the adventure, and settles with the men for their respective shares.

To many the most singular instance of this kind will be the use of the term *bachelor* women. Yet, as in Newfoundland, it originally denoted an unmarried person of either sex.

> He would keep you
> A *bachelor* still
> And keep you not alone without a husband
> But in a sickness.—Ben Jonson.

Scarcely less strange may appear the application of the term *barren* both to males and females. In the distribution of poor relief a complaint may be heard, "He is a barren man, and I have three children." So the word seems to have been understood by the translators of King James's version of the Bible. Deut. vii. 14: "There shall not be male or female barren among you."

Boughten, applied to an article, is used to signify that it has not been manufactured at home. The same use of the word was common in New England.

Bread with a Newfoundlander means hard biscuit, and soft baked bread is called *loaf*. The origin of this is easily understood. For a length of time the coast was frequented by fishermen, who made no permanent settlement on shore, and whose only bread was hard biscuit. In a similar way fish came to mean codfish.

Bridge, pronounced *brudge*, is the word commonly used to denote a platform, though the latter word is known or coming into use, but they generally pronounce it *flatform*.

Brief. A curious use of the word *brief* is to describe a disease which quickly proves fatal. "The diphtheria was very brief there," that is, it quickly ran its course ; the person died of it.

In several dictionaries (Standard, Halliwell, Webster, etc.,) this word is given as meaning "rife, common, prevalent," and is represented as specially applied to epidemic diseases. They also refer to Shakespeare as authority without giving quotations. Bartlett represents it as much used in this sense by the uneducated in the interior of New England and Virginia. Murray, in the New English Dictionary, gives the same meaning, but doubtingly, for he adds, "The origin of this sense is not clear. The Shakespearean quotation is generally cited as an example, but is by no means certain." I presume to think that the assigning this meaning is altogether a mistake. By no rule of language can *brief* be made to mean rife. We see at once, however, the expressiveness of the word as applied in the Newfoundland sense to an epidemic as making short work of its victims. I must regard this, therefore, as the original meaning of the word in this application. At the same time we can see how the mistake may have arisen. An epidemic disease so malignant as to prove fatal quickly could scarcely but become prevalent where introduced, and its prevalence being on the minds of men, they would be apt to attach such a meaning to the description of its working, as brief, and then use the word in that sense.

Similar to this is the use of the word *late*, applied to a woman lately married. "The late Mrs. Prince visited us," meaning the lady who had recently become Mrs. Prince.

Chastise is used not as particularly meaning to punish either corporally or otherwise, but to train for good. A father will ask the person to whom he is intrusting his son to chastise him well, meaning merely bring him up in a good way. But the more limited signification is coming into use.

The word *clever* it is well known is used in different senses in England and New England. In the former it expresses mental power, and means talented or skillful ; in the latter it describes the disposition and means generous or good-natured. In Newfoundland it is used in quite a distinct sense. It there means large and handsome. It is

applied not only to men, but to animals and inanimate things. A fisherman will speak of a "clever built boat," meaning that it is large and shapely. The dictionaries from Johnson onward give as one meaning of the word "well shaped or handsome." But he describes it as "a low word scarcely ever used but in burlesque or in conversation and applied to anything a man likes, without a settled meaning." Wright gives it as in the east of England meaning good looking and in Lancashire as denoting lusty, which when applied to men is nearly the Newfoundland idea, and probably the nearest to the old English.

Crop, commonly pronounced *crap*, the personal equipment of a man going on a sealing voyage supplied by the merchants but distinct from the provisions, etc.

Draft or *draught* in old English and still in the provinces means a team of horses or oxen, and also that drawn by them, a load. As the Newfoundlanders generally had no teams, they have come to use it to denote a load for two men to carry, hence two quentals of fish.

Dredge pronounced in Newfoundland *drudge*, is used to denote the sprinkling of salt over herring when caught, and mixing them together, to preserve them in the meantime. It is the same word that is used in cooking to denote sprinkling flour on meat for which we still have the *dredging box*. Skeat (Etym. Dictionary) gives a general meaning to sprinkle as in sowing *dreg*, *dredge*, mixed corn, oats and barley.

In connection with this they have the *dredge barrow* pronounced *drudge barrow*, a barrow with handles and a trough to hold salt, for carrying the fish from the boat to the splitting table.

Driver is the old English word for a four cornered fore and aft sail attached to the mizenmast of a vessel, now usually known as the spanker. It is now used in Newfoundland to denote a small sail at the stern of their fishing punts or boats. The rig I am informed was common among the fishermen of England and Jersey.

Drung'd or *drunge'd* equivalent to thronged of which it is probably a corruption.

Duckies. Twilight is expressed as "between the *duckies*," an expression which seems to resemble the Hebrew phrase "between the two evenings." So *duckish* meaning dark or gloomy, which Wright and Halliwell give as Dorsetshire for twilight. We may add here that the break of day is expressed as the *crack of the daanin*.

The word *fodder* is not used to denote cattle feed in general, but is limited to oats cut green to be used for that purpose. This use of the word I am informed is found in New England. So the words *funnel* and *funnelling* are used in Newfoundland and also in some parts of the United States for stove pipe. It is common in both to hear such expressions as that "the funnels are wrong" or "he bought so many feet of funnelling." This sense of the word has gone out of use elsewhere, except as regards a steamer's funnel.

Hatchet is used for an axe. This is a little singular as the word was not originally English, but is the French *hachette*, the diminutive of *hache*, and really meaning a small axe or hatchet.

Idle is used to mean wicked, expressing the full force of Watts' lines that "Satan find some mischief still, for idle hands to do."

A Newfoundlander cannot pass you a higher compliment than to say you are a *knowledgable* man. The word, however, I understand is common in Ireland, and I suppose was brought here by the Irish settlers.

Lodge is used in an active transitive sense, as equivalent to place or put, as "I lodged the book on the shelf," "She lodged the dish in the closet."

Lolly. This word is used by Newfoundlanders, as by the people on the northern coast of America, and by Arctic explorers, to denote ice broken up into small pieces. They have, however, another use of the word, so far as I know, peculiar to themselves, that is, to express a calm. In this respect it seems related to the word *lull*. Indeed, Judge Bennett thinks that it should be written *lully*.

Lot, the same as allot, to forecast some future event. Wright and Halliwell give it as Westmoreland for imagine, and the Standard Dictionary represents it as used in the United States as meaning to count upon, to pleasantly anticipate. The word *low*, which I deem a contraction of allow, is used in virtually the same sense. "I *low* the wind will be to the eastward before morning." The word allow is used in some parts of Nova Scotia as meaning intention or opinion. "I *allow* to go to town to-morrow." The Standard Dictionary represents it as colloquially used in this sense in the United States, particularly in the Southern States.

Main is used as an adverb, meaning very, exceedingly. A Newfoundlander will say, "I am *main* sorry," that is, exceedingly sorry.

This use of the word still appears in various provincial dialects of England. The word *fair* is also used in much the same way.

Marsh often pronounced *mesh* or *mish* is the usual name for a bog, of which there are many, and some of them very extensive through the island. So *pond* is the name for a lake. Even the largest on the island (fifty-six miles long) is known as Grand Pond. This usage prevails to some extent in New England, where however both terms are used without any clear distinction between them, but in Newfoundland "pond" alone is used. In this connexion, it may be also noted that a rapid in a river is usually known as a *rattle*, a term which I have not found elsewhere, but which I regard as very expressive.

Model, sometimes pronounced *morel*, is used in general for a pattern. Thus a person entering a shop asked for "cloth of that model," exhibiting a small piece.

Nippers, half mitts or half gloves used to protect the fingers in hauling the cod-lines.

The word *ordain* is in common use, and is applied to matters in ordinary business of life. Thus a man will say, "I *ordained* that piece of wood for an axe helve." This seems to be the retention of its original use, before it came to be set apart for the more solemn objects to which it is now applied. Similar to this is its use in Devonshire, according to Wright and Halliwell, as meaning to order or to intend.

The word *proper* is in very common use to describe a handsome well-built man. This is old English usage, as in Heb. xi. 23 : "He was a *proper* child." So in Scotch—

Still my delight is with *proper* young men.—Burns, *Jolly Beggars.*

Resolute is used in the sense of resolved. "I am *resolute* to go up the bay next week," meaning simply that I have made up my mind to that step. This was the original meaning of the word, but the transition was easy to its expressing a spirit of determination, boldness, or firmness, But it has come to have another meaning at least in some places, that of determined wickedness.

The word *ridiculous* is used to describe unfair or shameful treatment without any idea of the ludicrous. "I have been served most ridiculous by the poor commissioner," was the statement of a man who wished to express in strong terms his sense of the usage he had received. Halliwell says that in some counties in England it is used to denote some-

thing very indecent and improper. Thus, a violent attack on a woman's chastity is called very ridiculous behavior, and an ill-conducted house may be described as a very ridiculous one.

Rind as a noun is invariably used to denote the bark of a tree and as a verb to strip it off. The word *bark* on the other hand is only used as a noun to denote the tan which the fisherman applies to his net and sails, and as a verb to denote such an application of it. Thus he will say, "I have been getting some juniper or black spruce *rind* to make tan *bark*," or "I have been *barking* my net or sails," meaning that he has been applying the tannin extract to them.

One of the most singular peculiarities however of the dialect of Newfoundland, is the use of the word *room* to denote the whole premises of a merchant, planter, or fisherman. On the principal harbors, the land on the shore was granted in small plots measuring so many yards in front, and running back two or three hundred yards with a lane between Each of these allotments was called a *room*, and according to the way in which it was employed, was known as a merchant's room, a planter's room, or a fisherman's room. Thus we will hear of Mr. M's. upper room, his lower room or his beach room, or we have Mr. H.'s room, the place where he does business, at Labrador. One of these places descending from father to son will be called a family room.

Shall, probably the same as *shell*, but we find it as *shale* used by older writers. Johnson defines it as "a husk, the case of seeds in siliquous plants," quoting Shakspeare's line "leaving them but the shales and husks of men," and Halliwell gives it as a noun meaning "a husk" and as a verb "to husk or shell as peas."

The word *skipper* is in universal use and so commonly applied, as almost to have lost its original meaning of master of a small vessel. It is used toward every person whom one wishes to address with respect, and is almost as common as "Mr." is elsewhere. Generally the christian name is used after it, as skipper Jan, skipper Kish. In like manner the word *uncle* is used without regard to relationship. In a community every respectable man of say sixty years of age will be so called by all the other people in it.

Smoochin, hair-oil, or pomade. A young man from abroad, commencing as clerk in an establishment at one of the outposts, was puzzled by an order for a "pen'orth of smoochin." The verb *smooch* is also used as equivalent to smutch, to blacken or defile. We may hear such

expressions as, "His clothes are smooched with soot," or "The paper is smooched with ink." But it is also used to express the application of any substance as by smearing, without any reference to blackening. Thus one might say, "Her hair was all smooched with oil."

Spurt, a short time. "Excuse me for a spurt." "How long did you stay? Only a short *spurt*."

The term *trader* is limited to a person visiting a place to trade, in contrast with the resident merchants.

The mistress of a household disturbed in the midst of her house-cleaning will describe herself as *all in an uproar*. The word now denotes *noisy* tumult. But it originally meant simply confusion or excitement.

> His eye
> Unto a greater *uproar* tempts his veins."
> —Shakspeare, *Rape of Lucrece*, 4, 27.

Halliwell gives it as in Westmoreland meaning confusion or disorder, and so a Newfoundland lady uses it. But she has quite a vocabulary to express the same thing. She has her choice among such phrases as *all in a reeraw*, *all in a floption*, or *all of a rookery*. The last word, however, is given by Wright and Halliwell, as in the south of England, denoting a disturbance or scolding.

The word *weather*, besides the usual nautical uses to signify to sail to windward of, or to bear up under and come through, as a storm, is used to signify foul weather, or storm and tempest, according to an old meaning, now marked as obsolete, or only used in poetry. Thus Dryden

> "What gusts of *weather* from that darkening cloud
> My thoughts portend."

I have observed also that some words are used in the same sense as in Scotch. This is seen in the use of the preposition *into* for *in*. "There is nothing *into* the man," or as the Scotch would say "*intill* him." So *aneist*, meaning near or nearest. Then the word *vex* is used to denote sorrow or grief rather than worry. "I am *vexed* for that poor man," a Newfoundlander or a Scotchman would say, though I judge that it expresses grief arising to such a degree as deeply to disturb the mind. It is used in the same sense by Shakspeare.

> "A sight to *vex* the fathers soul withal "—*Titus Andronicus*, V. 1.

In one passage of the authorized version of the Bible (Isa. lxiii. 10) it is used to translate a Hebrew word everywhere else rendered grieve. So

the words *fine* and *finely* to mean very much or very good. "We enjoyed ourselves *fine*." "How are you to-day? O I'm fine." "He is doing finely." This usage could not have been acquired by intercourse with Scotch, as there are very few such on the island out of St. Johns. The last two words are from the Latin and come into Old English through the French, from which the use must have been separately derived.

III. I would now notice a number of words and phrases of a miscellaneous character, that have been introduced in various ways, or have arisen among the people through the circumstances of their lives.

I have already mentioned that though a large proportion of the population are of Irish descent, so as to affect the accent of the present generation, yet their dialect draws few words from this source. There are, however, some such. Thus we can scarcely mistake the origin of the use of the term *entirely* at the end of a sentence to give force to it. Then *path*, pronounced with the hard Irish *th*, was applied to a road or even the streets of a town. Not long ago one might hear in St. Johns of the "lower *pat-h*" or the "upper *pat-h*." So the use of the term *gaffer*, a contraction of *granfer*, itself a corruption of *grandfather*, as applied to children only, must have been derived from Ireland, in some parts of which it is common. From that quarter also came, if I mistake not, the use of the term *boys* in addressing men. It is used indeed to some extent elsewhere. English commanders, either of vessels or soldiers, use it when addressing their men in affectionate familiarity. Shakespeare also has it: "Then to sea, boys," "Tempest," II. 2. But the usage is specially characteristic of the Irish, and in Newfoundland it is universal, in whatever men are employed, whether on board a vessel or working on land. I believe that the use of the word *rock*, to denote a stone of any size, even a pebble thrown by a boy, which is universal in this island, is from the same quarter.

From the long time that the French have been fishing on this coast, we might have expected that the language of the residents would have received accessions from them. We find, however, only one or two words that we can trace to this source. Thus the word *pew*, an instrument consisting of a shaft with a sharp piece of iron like one prong of a fork at the end of it, used for throwing fish from the boats on to the stages, whence the verb to *pew*, to cast them up in this manner, seems to be the French word *pieu*, which is defined as meaning a stake or pale,

but which I am informed, is used by the French Canadians to denote a fork. On the west coast they have the word *Jackatar*, a corruption of *Jacque à terre*, Jack ashore, a name given to a Frenchman who has deserted his vessel and is living an unsettled life ashore, and indeed to any French Canadian from the St. Lawrence visiting that part of the island. The word *please* is used as an Englishman would say : "I beg your pardon, what did you say?" But this is simply the translation of the French *plaît-il.*

We would scarcely have expected to find their speech set off by importations from the classics. But some words seem to be of Latin origin. In the prices current in the newspapers one may see fish distinguished as *tol squolls* or *tal squals* and quoted at certain figures. This denotes fish bought and sold without assorting or culling, just as they come. Dr Pilot suggests that the word is a corruption of the Latin *talis qualis*, such as it is, and it is likely that he is correct.

Another word which he regards as of classic origin is *longer*. This he supposes a contraction of the Latin *longurius*. I do not think it necessary to go beyond the English language to account for the formation of the word. At all events, it is used in Newfoundland to denote a pole, of length according to circumstances, stretched across an open space. Thus they have *flake longers*, the horizontal pieces in flakes, on which boughs are laid to form the bed on which fish are placed to dry ; *fence longers*, small sized fence rails ; and *stage longers*, of larger size, from five to seven inches in diameter, forming the floor or platform of the fishing stage.

There is another word in common use, which seems to me to have a Latin origin, that is *quiddaments*, which means the things necessary in travelling. To me it seems simply a corruption of *impedimenta*, which meant exactly the same thing, though others prefer deducing it from the word *accoutrements.*

It will be seen that several of the old English words in use in Newfoundland are also found in New England. The question has been raised whether each derived them from their common English parentage, or whether the Newfoundlanders received them by intercourse with New England fishermen visiting their coast I am decidedly of opinion that most if not all the words of this stamp used in Newfoundland were an original importation from the mother country. The intercourse of New England fishermen was too limited and too transient to have so

generally affected their language. Still there are a few words in use which seem to have come in that way, for example, *callibogus*, a mixture of spruce beer and rum; a *scalawag*, a scamp; *tomahawk*, the name by which the American shingling hatchet is known; *catamaran*, a word originally denoting a raft of three logs lashed together, used first in the East and afterwards in the West Indies; but in Newfoundland used to denote a woodshed, and when side sleighs were first introduced, applied to them; and *scrod*, in New England *escrod*, a fresh young codfish boiled.

There is a word common in names on the coasts of Newfoundland and Labrador to which I must advert It is the word *tickle*, used to denote a narrow passage of some length, usually between an island and the mainland, sometimes large enough to afford shelter for vessels, and sometimes so small as to be navigable only by boats. On the east coast of Newfoundland there are six or eight such places, known by particular appellations, as North Tickle, Main Tickle, &c., and the Coast Pilot notes over a dozen such places on the Labrador coast. We have other names formed from them as Tickle Point or Tickle Bay. In two or three instances in Nova Scotia and New Brunswick we have such a place known sometimes as a *tickle*, but commonly as a *tittle*, which I deem a corruption of it. I have never seen a conjecture as to the meaning or origin of the word, but myself proposed the following explanation.* The first explorers of the coast referred to were the Portuguese, who gave names to the leading places on these shores, a number of which remain to the present day. A large proportion of these were the names of places in Portugal or the Western Islands, from which they carried on much of their trade. Now on the coast of Portugal may be seen a point called Santa Tekla. It is a narrow projection some miles in length, inside of which is a lengthy basin, narrowed by an island. As there were few good harbors on the coast of that country, this formed a favorite resort for shelter, particularly to her fishermen. What more natural than that they should give the name to places here of similar appearance and serving the same purpose. The slight change from Tekla to Tickle will not appear strange to any person who knows into what different forms foreign words have been changed when adopted by Englishmen.

* Transactions of the Royal Society of Canada, VIII. (2). 141.

IV. From the population of Newfoundland being so generally a seafaring people, they have in use many technical terms connected with nautical life. Some of these are common with English sailors. Thus they have the word *lobscouse*, originally *lobscourse*, as in Peregrine Pickle, still farther contracted into *scouse*, a sailor's dish, consisting of salt meat, stewed with vegetables and ship's biscuits. To this they give the name *scoff*, which seems to be related to the verb *scoff*, given as a slang nautical term, meaning to eat voraciously (see Standard Dictionary).

An odd phrase among them is *Solomon Goss's birthday*. It is applied to Tuesdays and Fridays as pudding days, when at the seal or cod fishing. What is the origin of it, or whether it is peculiar to the people of Newfoundland, I cannot ascertain.

But I would specially note the technical terms connected with their fishing. From the intercourse which has taken place for over two centuries between fishermen in Newfoundland and those of the adjoining coasts of America, and even between them and those of European nations, it was natural that the same terms should be used among them, though some seem to be peculiar to Newfoundland or are there used in a peculiar way.

Thus *flaik* or *flake* is an old English word for a paling or hurdle. In old Icelandic it appears as *flaki* or *fleki* especially a hurdle or shield of wicker work, used for defence in battle (Vigfussen Icel. Dictionary). Webster gives it as "Massachusetts for a platform of slats of wands or hurdles, supported by stanchions, for drying fish." But it has long been used in this sense in Newfoundland, and the adjoining coasts of British America, and it is now admitted into the dictionaries as a good English word.

A curious custom is described in the phrase a *press pile compass*. A *press pile* is fish piled up to make, and a *press pile compass* is a trick played on a green hand of sending him to the next neighbor to borrow the press pile compass. The party applied to has not one to spare and sends him to the next, and so on as on April fool's day.

The fishermen of Newfoundland have a fishing-boat known as a *jack*, said to be peculiar to that island. It is from seven to fifteen tons' burden. The deck has open standing spaces forward and aft for the fishermen to stand in while they fish. The deck is formed of movable boards. It is schooner-rigged, but without either fore or main boom. The foresail is trimmed aft by a sheet, and the mainsail trimmed aft to

horns or pieces of wood projecting from the quarters. It thus avoids the danger of either of the booms knocking the fishermen overboard. I cannot ascertain the origin of the name, but it is believed that it was brought from either England or Ireland.

Among the curious words connected with their fishing I would farther note the following: *downer*, a heavy squall of wind; *sunker*, a breaker; *roughery*, a heavy sea on; *collar*, a mooring laid down for the purpose of fastening the fishing punt or craft to it, the rope has a loop at the end for pulling over the stern of the boat, and this gives its name to the mooring; *faggots*, small piles of fish on the flakes; *high rat*, a boat with a board along the edge to prevent the water coming over, called a *washboard*, a term applied to objects which have a similar arrangement; thus a man boarding in town complained that he had to sleep in a bed without any washboard; *rode*, the hemp cable by which the vessel, boat or punt rides on the fishing ground and *waterhorse*, a pile of fish after having been washed, usually three or four feet wide, about the same height, and as long as may be.

Voyage, is used to express not their passage from one place to another, but the result of their trip. A good voyage is one in which they have been successful in their object whether fishing or trading and a bad voyage the reverse.

From their fishing seems also to have come the use of the word *sign* in the phrase, "a sign of" to express a small quantity. One at table being asked if he would have any more of a certain dish replied, "just a sign." When after reaching the fishing grounds and seeking spots where fish were to be found, they first caught some, it afforded a *sign* of their presence, just as a gold miner speaks of a "show" of gold. When they caught them in greater abundance they spoke of having "a *good* sign of fish." Hence the term I believe came to be applied generally to denote a small quantity.

Being so much dependent on the weather, as might be expected they have peculiar words and expressions regarding it. Thus a calm day is *civil* and a stormy one is *coarse*. This last is given by Halliwell as in various dialects of England, and it is also common in Scotland. A very sharp cutting wind driving small particles of congealed moisture, which cut the face in a painful manner, is expressively called a *barber*. On some of the coasts of the provinces, the term is applied to a vapor arising from the water in certain states of the atmosphere, and this sense is

given in the Standard Dictionary. In Newfoundland, however, I am assured it has always the idea connected with it of a cold wind driving the particles of ice in a way as it were to *shave* ones face.

They have also some peculiar names for the creatures coming under their notice. Thus the *medusae* or sea nettles are called *squid squads*, sometimes *squid squalls*, the echinus or sea urchin *oxeggs*, fresh water clams, *cocks and hens*, and to the westward smelts are known as *ministers*. The black fly is known as the *mosquito* and the musquito as the *nipper*. The sea eagle they call the *grepe*. This seems unquestionably the same as *grebe*, but originally it represented certain kinds of water fowl. Then *stout* is used for *shoat*, a young pig, and the American brown thrush or robin is called *the black bird*. We may add here that raisins are always known as *figs*, while figs are distinguished as *broad figs*.

But seal hunting is the industry peculiar to the island and in it has arisen a large number of terms, either specially applied or sometimes seemingly produced among themselves, to denote every object and act connected with it. We should observe however that with them a seal is always a *swile*, a sealing vessel or sealer, a *swiler* and seal hunting is *swile hunting*. This is an example, of which there are many others, of words being pronounced so differently as really to seem to be different words. Thus a hoe is a *how*, the fir is *var*, snuffing is *snoffing*, forked is *varket* and never is *naar*, which is equivalent to "not," "naar a bit" being a favorite expression to denote a strong negative.

Then they have a number of words only to distinguish the species of seals, as *harps*, *hoods* and *dogheads*, but to mark the difference of age and condition. Thus the young or baby-seals till they leave the ice are known as *whitecoats*. When the pelt, that is the skin and fat together, does not weigh more than twenty-five pounds, it is called a *cat*, and a dwarf-seal, a fat little fellow, is called a *jar*.

The most curious use, however, of a word in this connection is that of *bedlamer*. The word originated with a class of vagabonds in the Middle Ages, known at first as "bedlam beggars," so called because when released from Bedlam hospital they were licensed to beg. They are referred to by Shakespeare as pilgrim beggars, but were commonly known as Toms o' Bedlam. They were also called bedlamites and *bedlamers*, which came to be generic terms for fools of all classes. The last is used in Newfoundland with two applications: (1) It denotes a seal one year old and half grown, which being immature is of little

value, and (2), it is applied rather contemptuously to young fellows between 16 and 20. Where we would apply to them such a term as hobbledehoys, a Newfoundlander would always call them *bedlamers*. Judge Bennett says, "I have often had them so described in court. A policeman will say there were a lot of *bedlamers* standing at the corner, and accused was one of them," etc. There is sufficient resemblance between the two classes to account for the use of the same name, but how this came first to be applied to either does not appear.

Again for their work on the ice they have their own terms. Thus a cake of ice is uniformly known as a *pan* of ice, and to *pan* is to gather to one place a quantity say of seals. This last, however, seems a survival of an obsolete English word meaning to join or close together. Ice ground fine is known as *swish* or *sish* ice, but broken into larger pieces is called *slob ice*, to either of which also might be applied the term *lolly*, in common use on the North American coasts. When by the pressure of sea and storm the ice is piled in layers one upon the other, it is said to be *rafted*. Large cakes of ice floating about like small ice-bergs are called *growlers*. Through the melting of the part under water they lose their equilibrium, so that sometime even a little noise will cause them to turn over with a sound like a growl. Hence their name. Driven by high winds they acquire such momentum that they carry destruction to any vessel crossing their course. One year so many accidents occurred from them, that it was known as the year of the growlers. The process of separating the skin of the young seal with the fat attached is called *sculping*, and the part thus separated is known by the *sculp*. This is also known as the *pelt*, in seal hunting that term always including the fat attached, though in hunting on land it is used to denote the skin alone. To these we may add *swatching*, watching open holes in the ice for seals to come up to shoot them, simply a corruption of seal watching.

Being so much engaged with the sea, all their expressions are apt to be colored by life on that element. Thus a person going visiting will speak of going *cruising*, and girls coming to the mainland to hire as servants will talk of *shipping* for three months, or whatever time they propose to engage.

Independent of the sea, however, they have a number of words which seem to have been formed among themselves, some of which may be regarded as slang, but which are in common use. I notice the following

bangbelly, a low and coarse word denoting a boiled pudding consisting of flour, molasses, soda, etc., and not uncommonly seal-fat instead of suet. I think we need hardly go searching for the origin of the name *chin* or *cheek music*, singing at dances, where they have no fiddle or accordeon, as often happens among the fishermen ; *elevener*, given by Halliwell as in Sussex denoting a luncheon, but in Newfoundland meaning a glass of grog taken at eleven o'clock, when the sun is over the fore yard ; *gum bean*, a chew of tobacco ; *ear winkers*, flannel coverings for the ears in winter ; *ramporious*, a sort of slang term, describing parties as very angry and excited, yet it seems well formed English, having its root-word *ramp*, and being kindred with *rampage*, *rampant*, *rampacious* or *rampageous*, with the last of which it is nearly synonymous ; and *locksy*, regarded as a corruption of *look see*, but probably the first part is a form of the Anglo-Saxon *loke*, according to Halliwell, meaning to look upon, to guard, to take care of.

V. Lastly. There are a number of words, of which I am unable to trace the origin or relations. Thus a species of white bean is advertised commonly and sold under the name of *callivances*. Eggleston, in an article in the "Century Magazine" for 1894, mentions "gallivances and potatoes" as given in 1782 among the products of Pennsylvania, and in the same year, in "a complete discovery of the State of Carolina," a list is given of several sorts of pulse grown in the colony, "to wit, beans, pease, callavances," &c. He is puzzled about the word and supposes it to mean pumpkins, and to be from the Spanish *calabaza* (gourd). But they would not be pulse. Probably it meant there as it now does in Newfoundland, the small white bean, in contrast with the broad English bean. But what is the origin of the word, and how did it come to be found in places so distant and in circumstances so different as in Carolina and Newfoundland? And is it not singular to find it surviving in the latter when it has elsewhere disappeared so entirely, that the learned are unable to ascertain its meaning?

Of other words to me of unknown origin I note the following :— *babbage*, used to the northward to denote the plaiting of a snowshoe ; *baiser*, applied by boys fishing, to a large trout ; when such is caught, a common exclamation is, "Oh, that's a baiser ;" *ballacarda*, or *ballaca-dar*, ice about the face, also ice along the foot of the cliff, touching the water ; *chronic*, an old stump ; *cockying* in Harbor Grace, *copying* in St. Johns, describing an amusement of boys in spring,

when the ice is breaking up, springing from cake to cake in supposed imitation of the seal hunters; *covel*, a tub made to hold blubber or oil; *cracky*, a little dog; *crannocks* on the west coast, *crunnocks* to the north, small pieces of wood for kindling fires; the *diddies*, the nightmare; *dido*, a bitch; *gandy*, the fisherman's name for a pancake; *dwy*, a mist or slight shower. "Is it going to rain to-day?" "No, its only a dwy," a Newfoundlander may reply. So a *snow dwy* denotes a slight fall of snow, which is not expected to come to much; *farl* or *varl*, the cover of a book; *gly*, a sort of trap made with a barrel hoop, with net interwoven, and hook and bait attached, set afloat to catch gulls and other marine birds known as *ticklaces* and *steerins*, but what species is meant by the last two names I have not ascertained; *jinker*, there is such a word in modern English, connected with jink, denoting a lively, sprightly girl, or a wag, but among the Newfoundlanders the word must have had a different origin, as with them it means an unlucky fellow, one who cannot or does not succeed in fishing; *old teaks* and *jannies*, boys and men who turn out in various disguises and carry on various pranks during the Christmas holidays, which last from 25th December to old Old Christmas day, 6th January; *matchy*, tainted, applied to salt beef or pork supplied to the fishermen; *pelm*, any light ashes, such as those from burnt cotton, card-board, &c., also the light dust that arises from the ashes of wood and some kinds of coal; *scrape*, a rough road down the face of a bank or steep hill, used specially in regard to such as are formed by sliding or hauling logs down; *shimmick*, used on the west coast as a term of contempt for one who born of English parents, attempts to conceal or deny his birth in Newfoundland; *sprawls*, scil. of snow, heavy drifts; *sprayed*, describing chapped hands or arms; *starrigan*, a young tree, which is neither good for firewood, or large enough to be used as timber, hence applied with contempt to anything constructed of unsuitable materials; *tolt*, a solitary hill, usually somewhat conical, rising by itself above the surrounding country; *truckly muck*, a small two-handed car for dogs, with a handle for a man to keep it straight; *towtents*, pork cakes, made of pork chopped fine and mixed with flour; *tuckamore*, in some places *tuckamil*, a clump of spruce, growing almost flat on the ground, and matted together, found on the barrens and bleak exposed places; and *willigiggin*, half between a whisper and a giggle.

A large proportion of the people of Newfoundland being uneducated, persons trying to use fine English words often substitute one for another

somewhat alike in sound but totally different in meaning. Sometimes these are as ludicrous as any that have appeared under the name of Mrs. Partington. Dr. Pilot has given a number of instances of this kind, as *biganous* for bigoted, meaning obstinate in his opinions, *circus court* for circuit court, *commodation* for recommendation, as for example, a servant's character. And we have heard a good janitor of a church having his feelings hurt by being obliged to use *antichrist* (anthracite) coal. Then there are words variously mangled in the pronunciation by the ignorant, as *dismolish* for demolish, and *nonsical* for nonsensical. Such a use of words is generally very limited, perhaps not extending beyond a single individual. In any case they are simply the blunders of the ignorant, and unless commonly adopted are of little interest to the student. Sometimes a word does thus come into use, as may be seen in the word *expensible* for expensive.

Like all uneducated people they have idomatic phrases or a sort of proverbial expressions. often based on the circumstances of their daily life, which are frequently expressive. Thus they will describe a simpleton or greenhorn as *not well baked* or *only half baked.* They will also describe a similar character as having *a slate off,* indicating the same that is meant by a man having something wrong in his upper story. This saying was doubtless brought with them from the old country ; but as slates are not used among them for the covering of houses, they have adapted the saying to the country by speaking of such a man as having *a shingle loose.* An increase of cold may be described as the weather being *a jacket colder* and when feeling its severity they speak of being *nipped with cold.* Again, a man describing his poverty said he had nothing to eat but *a bare-legged herring,* meaning a herring without anything to eat with it. So *stark naked tea* is tea without milk or sweetening, or *sweetness,* as the fishermen call it, molasses being known as *long sweetness* and sugar as *short sweetness.* To *put away a thing too choice* is to lay it aside so carefully as not to be able to find it. To *pay ones practice* is to pay the accustomed dues to the minister or doctor. *Over right* is for opposite or against. To *put your handsignment* is to sign your name. When a fisherman has a good catch of fish he has taken a *smart few,* but if he has met with only partial success he has only caught a *scattered few,* and if fish have been very scarce he will describe himself as getting only a *scattered one.* Quite an expressive phrase is *getting into*

collar to denote working on a ship preparatory to sailing either for seal or cod fishing. A curious one of which I can get no explanation is *she'd lick her cuff*, that is, submit to any humiliation, to be let go to a dance or secure what object she has in view. But one of the most amusing uses of a word is that of *miserable* simply as intensive. Thus a person will speak of a *miserable fine day*. Occasionally there is something poetic in their expressions, as when the land is described as just *mourning for manure*.

In these two papers I am far from having exhausted the subject, but I believe that they will be sufficient to show that in the peculiarities of Newfoundland speech we have an interesting field of inquiry. Here is a people living in a secluded position, but retaining words and forms of speech brought by their fathers from England, which elsewhere have passed away entirely, or are preserved only as provincialisms in some limited districts. In this quarter the study of these has been neglected hitherto. Persons laying claim to education have regarded them simply as vulgarisms, and have expressed some surprise that I should have deemed them worthy of thoughtful investigation. They could scarcely conceive that the rude speech of unlettered fishermen was really part of the language of Shakespeare, Milton and Chaucer. What I have done will, I trust, stimulate further enquiry, and that without delay. Education and intercourse with people of other lands will soon modify if not entirely wear away these peculiarities. It is to be hoped, therefore, that while the opportunity lasts there will be found among those having intercourse with them, persons to prosecute the inquiry farther, and to seek to gather the fullest information on a subject interesting in itself, but especially so as bearing on the past of our English mother-tongue.

Remarks on the subject of Dr. Patterson's paper were made by W. H. Harrington, Esq., and Dr. Reid.

Seventh Ordinary Meeting.

Legislative Council Chamber, Halifax, 11th May, 1896.

The President in the chair.

It was announced that W. Hague Harrington, Esq., F. R. S. C., of Ottawa, Canada, had been elected a Corresponding Member at the last meeting of the council.

In the absence of the author, DR. MACKAY read a paper entitled, "Notes on the Geology of Newfoundland," by T. C. WESTON, ESQ., F. G. S. A., of Ottawa. (See Transactions, p. 150).

The paper was discussed by the PRESIDENT and DR. MACKAY.

DR. MACKAY then presented a paper entitled, "Phenological Observations for 1895." (See Transactions, p. 195).

A paper by W. H. PREST, ESQ., of Chester Basin, on "Glacial Succession in Central Lunenburg," was read by MR. PIERS. (See Transactions, p. 158).

Remarks on the subject were made by DRS. MACKAY and MURPHY.

The following papers were then read by title :—

"On the Flora of Newfoundland; No. 3." By REV. ARTHUR C. WAGHORNE, New Harbour, Newfoundland.

"Notes on Nova Scotian Zoology; No. 4." By HARRY PIERS, ESQ.

"Water Supply of the Towns of Nova Scotia." By PROF. W. R. BUTLER, M. E., King's College, Windsor.

"On the Broad Cove Coal Field." By W. H. ROSS, ESQ.

On motion, it was resolved to authorize the Council to regard as having been read by title certain papers which were to have been communicated at the present meeting, but had not yet been received.

HARRY PIERS,
Recording Secretary.

THE

Proceedings and Transactions

of the

Nova Scotian Institute of Science,

HALIFAX, NOVA SCOTIA.

SESSION OF 1896-97.

VOLUME IX

(Being Volume II of the Second Series)

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1896-7.

ANNUAL BUSINESS MEETING.

Legislative Council Chamber, Halifax, 9th November, 1896.

The PRESIDENT, DR. GILPIN, in the chair.

The PRESIDENT addressed the Institute as follows :—

GENTLEMEN,—I have much pleasure in meeting you to-night. I present myself your representative to mark the close of another year of the existence of the Institute, and to inaugurate a new session.

In one sense, I may claim to be numbered among the oldest of those who have been interested in this Society. Although it is nearly a quarter of a century since I was allowed to read my first paper before you, there are a number of you who have been for a much longer period members.

I remember, however, being present and watching as a boy the initiatory meeting of the Institute, being the more interested as the late Dr. Gilpin, who read the first paper in our proceedings, took an active part. Almost all the original members have now ceased from work, but their record remains.

From its commencement, the Institute members have ranged over all the fields of science open to observers in this Province, and have recorded their opinions and deductions according to the lights of their days. Their arguments may now be displaced or amended in the focus of the science of to-day or to-morrow ; the facts they have accumulated

remain, and we may feel satisfied if we have contributed our quota of bricks to the daily increasing foundation of the sciences.

In every division of nature our deductions and laws remain good until rendered untenable by the unanswerable chill of fresh facts. The true student rejoices at the demolition of his fabric when he knows that the opportunity is offered of modelling it on a broader and surer foundation.

It is largely in the accumulation of facts that a useful future lies before us, and I would impress upon you the desirability of enrolling every person who can give careful and accurate observations upon the natural world surrounding us.

One discovery by one of our members of an important fact bearing on the protection of our agricultural products from the attacks of noxious insects, the introduction of a form of animal or vegetable life capable of anchorage here, and serving to our needs, or any similar discovery, would many times repay the money we have spent. We should have on our list every person willing to study in these or kindred branches, and to such substantial assistance should, I think, not be denied by you.

The transactions of the past session of the Institute will, I think, be considered, to say the least, quite up to the mark. Of most general interest will be found the portrait of our late friend, Dr. Lawson, and Prof. MacGregor's sketch of his busy and useful life. In addition to the regular papers, matters of interest were submitted at various meetings by Prof. MacGregor, Drs. MacKay and Somers. At a special meeting the Rev. G. Patterson read a valuable paper on "Newfoundland Folk Speech."

In the Transactions are two linked papers by Prof. MacGregor and D. McIntosh on the calculation of the conductivity of mixtures of electrolytes. The former showed by a graphical process, based on observations, the calculability of the conductivity of a series of mixtures of solutions of chloride of sodium and potassium. He found that the calculations agreed with the observations in dilute solutions, but not in stronger ones. The latter extended the observations in order to determine the differences between the observed and calculated values in the case of the stronger solutions, and the extent of agreement in the case of solutions of sodium chloride and hydrochloric acid which have ionic velocities differing more widely.

Among the geological papers is one on the unexplored coal fields of Nova Scotia by me, and an interesting note by Mr. T. C. Weston on a few new paleontological facts, and on the general similarity of the fossil faunas of the silurian of Canada and Newfoundland. Mr. Prest, in a paper on Glacial Succession in Lunenburg County, differs somewhat from the conclusions arrived at by the Geological Survey. Professors Bailey and Coldwell have referred in two papers to the Superficial Geology of Kings and Queens Counties, the former referring also to interesting exhibits of faulting, metamorphism, vein filling, contacts, etc. Dr. Somers has contributed a note on Juniperus Communis, from which it appears that instead of one variety, the most common, decumbent, being only found here, there is another less common having a shrubby form. I am pleased to be able to inform you that the Doctor has promised further contributions on botanical subjects.

Dr. MacKay has continued his important summaries of the reports of phenological observations made under the auspices of the Botanical Club of Canada.

The Transactions close with an interesting paper by Mr. Piers, our Recording Secretary, on the Orthoptera of Nova Scotia. I understand that he proposes to extend this paper, which embraces a study of much value to our agriculturists.

I think that it is now in order for me to thank you for your kindly consideration of the office of President during the past year. I feel that a good Council and a faithful staff of officers have combined not only to make his path easy, but to maintain and promote the progress of the Institute. To the Treasurer, the Librarian, and to the Secretaries, the thanks of the Institute are justly due. Having done so little myself, I can the more fairly estimate the value of their labors, and can honestly say, I believe, that if the members would treble their numbers they would so much the more willingly discharge their increased tasks.

It has occurred to me that a few remarks on the system of instruction and examination of mining officials instituted by the Government of this Province, may be of interest.

The Institute proceedings contain many papers upon geological and allied subjects, and any efforts tending to increase the observing and recording powers of those directing our mining operations cannot fail to be appreciated by you.

Wherever communities are engaged in a particular occupation, a certain average level of intelligence prevails. This standard never sinks below that essential to the earning of the wage paid, but it is with difficulty raised. The prominence of individuals due to their greater physical strength, or to the more practical application of their mental power to the subject of their work, excites envy rather than emulation. In such communities the first step upward is resistance against encroachments by the employer. Unions follow. In many cases this coalition of labor has no aims beyond the preservation of wages against reduction, and their increase at every opportunity. In some instances attempts have been made at boards of conciliation and arbitration, and sliding scales. These aspirations, however, are but the outcome of that experience of unionism which has shown that facts and natural laws must be considered, and may be called a selfish extension of the original scheme.

In Nova Scotia, the most powerful labor union is perhaps that of the coal miners. Its organization has given occasion for a conciliation and arbitration act, which promises well, altho' it has not yet undergone the ordeal of practical application. The outcome, however, of this organization, more interesting and ultimately useful, is that relating to education.

It was recognized by those who were mainly interested in the objects of the Provincial Workman's Association, and especially by the Hon. R. Drummond, the Grand Secretary, that the proper conduct of the business of the various lodges, the proper estimation of the social problems of politics, supply and demand, etc., thus suddenly presented, and the intelligent discussion of the labor and mining problems most directly affecting them, required that the intelligence and education of the members should be materially assisted. It soon became apparent that the better the members understood the problems of the miners' occupation the less liable were the different unions to be hurried passionately into ill-advised and half-considered conflicts with capital. It was also evident that the better the status of the subordinate officials about the mines the more the safety of the miners was secured. After some discussion it was agreed that the experiment should be tried of fixing a standard for underground managers and overmen. The necessary statutory power having been granted by the government, an order-in-council appointed a Board of Examiners tentatively. As experience was gained, changes were made until the present system, which has worked satisfactorily for some time, was established.

The Province, for the purpose of the Board, has been divided into three districts—Cumberland, Pictou, and Cape Breton. From each of these districts are appointed two men representing respectively the companies and the workmen, and a third, as far as possible, a mining engineer not interested in the operations of any company. The Inspector of Mines acts as Secretary and the representative of the Government on the Board. The questions are prepared by the Board at a full meeting; the examinations held simultaneously by the local divisions of the Board; and the answers considered at a full meeting of the Board.

It was soon found that many candidates were deficient in surveying and the knowledge of arithmetic, logarithms, geometry, etc., necessary for the solution of the problems of ventilation, etc. The most intelligent of the successful candidates, in many cases men who had unaided made themselves masters of these subjects, were appointed instructors for the candidates. In this way an annual course, some months in length, has been established at the principal collieries, about ten instructors being employed. The expenses of these schools are met by the Mines Department, and each teacher receives a fixed fee, contingent upon his presenting at least two candidates, in addition to a fee for each candidate that passes a successful examination.

The first certificate of competency was issued March 15th, 1883, and since that date 121 certificates have been issued to underground managers, 146 certificates to overmen, in addition to 32 certificates of service to those holding these positions at the time the law came into force. This system has established an ample supply of men for our own collieries, and those leaving our shores find their certificates a good passport to respectable positions abroad. The conditions of admission for a candidate are that he be at least twenty-one years of age, of good reputation, and have been employed at least five years underground. The readiness and precision of the answers of many of the candidates would do credit to examinations of a much more pretentious character.

It was finally decided that the provisions of the act should be extended to mine managers, and the powers of the Board were amplified. In all 41 certificates have been issued to managers. Quite a number of those holding manager's certificates are working miners who have successively passed the different examinations, one after the other, with intervals required to attain the additional knowledge. In one instance a foreigner, unable to speak or write in the English language when he

arrived a few years ago, has passed, not without failures, until he has been appointed a manager of a coal mine. This instance, perhaps the most extreme, illustrates the fact that the advantages offered by this scanty system of education are well received by the more ambitious and intelligent of our miners. In the end the lodges at the different collieries have profited as well as the mines, for I am informed no small percentage of their officials and leading men are holders of certificates. The fact that the miners recognize the fitness of such men to be their guides and advisors is a strong argument that moderation and wisdom will mark their deliberations.

As you know, at nearly all of our coal mines the men are raised from and lowered to the scene of their work by machinery. The drivers of these engines are always selected with much care, as they require to be reliable and steady men. It was decided that, in order to increase the margin of safety, these men should undergo examination as to their knowledge of boilers, machinery, etc. A Board of three mechanical engineers was appointed representing, as in the case of the Board I have already referred to, the three principal coal districts. The examinations are conducted in a similar manner, and already 74 certificates have been issued, including those certificates of service granted those engineers found worthily filling their positions at the time the law was passed. Whenever a class of candidates offers, mechanical instructors are appointed on the principle described already.

I may mention that the work of the instructors and boards has been facilitated by the provision made by law for the establishment of night schools in mining and other districts. Many candidates, as might be expected, however good their practical knowledge and experience may be, are deficient in the exact grounding required for examination. They can remedy this by attending the night schools, and the mining instructors are thus relieved of much drudgery and able to teach the essentially mining subjects with greater detail.

As is well known, the strength of a chain is precisely that of the weakest of the links composing it. In mining, however careful the overmen and watchmen may be, one ignorant or careless workman may nullify all their efforts and precautions, and in a moment lose his own or another's life, cause an explosion, or a fire. In order, therefore, that there might as far as possible be no lack of endeavor to make all safe, it

was determined that the miners themselves should be examined as to their practical experience and knowledge. This has been carried out, and I believe there is not a coal miner working to-day, except perhaps in a few mines open only a few months in the winter, who is not the holder of a certificate. After a certain period of employment under ground as loader, driver, etc., he is permitted to assist in cutting coal. The miner, however, in charge of the place in which he works and assists, is the holder of a superior certificate secured by examination. These examinations and the issue of certificates is effected through local boards appointed at each colliery and paid by a small fee.

These boards also examine applicants for the position of shot firers. These are men who are, under certain conditions of the mines, appointed to supervise the firing of the charges of gunpowder or other explosive used in blasting the coal. I may say these examinations of miners and shot firers are *vivâ voce*, all the others being by written answers.

While the business connected with these examinations has added materially to the work of the Inspector of Mines, it is a satisfaction to know that the results so far have been encouraging. The standard exacted from the candidates compares well with that required in other countries. The Government and people of Nova Scotia may feel pleased that in this respect we have gone ahead of other countries, and have made a successful attempt to place within the reach of every coal miner in the Province the means of his advance to a state of education, and an opportunity of fitting himself for responsible and respectable positions.

While explosives are permitted in coal mines, and while work is necessary in dangerous atmospheres with lamps liable to accident, even with the greatest care in manufacture and use, so long must the recurrence of disasters be expected. I will not dwell upon this subject, but wish to point out that the mining authority of the Province has taken every step possible to minimise these dangers by its examinations of men and officials

The thanks of the Institute were presented to the President for his interesting address.

The report of the Treasurer was read and approved. The accounts had been audited by Messrs. Morton and O'Hearn and found correct.

The Report of the LIBRARIAN was presented by PROF. J. G. MACGREGOR. During the past year copies of the Transactions had been sent for the first time to 6 institutions in the United States, 3 in Canada, 2 in Germany, and 1 in England, and exchanges had been received for the first time from the following :—

Swedish Society for Anthropology and Geography, Stockholm.
Central Observatory, Xalapa, Mexico.
Natural Science Society, Carlsruhe.
Natural Science Society, Elberfeld.
Geographical Union of the North of France, Douai.
University of Vermont, Burlington, Vt.
Museum and Library of Filopenas, Filopenas.
Literary and Philosophical Society, Liverpool, G. B.
Royal Society of the Natural Sciences, Buda-Pest.

But few books had been bound owing to a lack of funds, consequent upon our having published in one year two annual Parts of the Transactions. Owing to lack of accommodation at the Post Office building it had been found necessary to remove the Canadian and Australian publications to the room courteously furnished at Dalhousie College by the Board of Governors. The only sections of the Library now at the Post Office building are the British and United States publications. The members had not made so much use of the Library as in other recent years, doubtless because of the increasing difficulty in gaining access to the books.

A vote of thanks was presented to MR. BOWMAN and PROF. MACGREGOR for their work in connection with the Library.

The following officers were elected for the ensuing year (1896-7) :—

President—E. GILPIN, JR., ESQ., LL.D., F.R.S.C.
Vice-Presidents—ALEXANDER MCKAY, ESQ., and A. H. MACKAY ESQ., LL.D., F.R.S.C.
Treasurer—W. C. SILVER, ESQ.
Corresponding Secretary—PROF. J. G. MACGREGOR.
Recording Secretary—HARRY PIERS, ESQ.
Librarian—MAYNARD BOWMAN, ESQ., B.A.
Councillors without office—MARTIN MURPHY, ESQ., D. SC.; F., W. W. DOANE, ESQ., C.E.; WILLIAM MCKERRON, ESQ.; WATSON L. BISHOP, ESQ.; S. A. MORTON, ESQ., M.A.; P. O'HEARN, ESQ.; RODERICK MCCOLL, ESQ., C.E.

It was resolved that the thanks of the Institute be conveyed to the HON. R. BOAK for his courtesy in permitting the use of the Legislative Council Chamber for the meetings of the Society. Also resolved that the thanks of the Institute be presented to the Secretary of the Smithsonian Institution, Washington, for his courtesy in granting the Institute the privileges of the Department of International Exchanges of the Institution.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 9th November, 1896.

The PRESIDENT in the chair.

PROFESSOR J. G. MACGREGOR, D. SC., read a paper "On the Relation of the Physical Properties of Aqueous Solutions to their State of Ionization." (See Transactions, p. 219).

The paper was discussed by MR. A. MCKAY, DR. A. H. MACKAY, and others.

SECOND ORDINARY MEETING.

Legislative Council Chamber, Halifax, 14th December, 1896.

The PRESIDENT in the chair.

It was announced that the following gentlemen had been elected members of the Society :—LEE RUSSELL, ESQ., B. SC., Normal School, Truro ; T. C. MCKAY, ESQ., B. A., Dartmouth ; REV. BROTHER PETER, La Salle Academy, Halifax ; CHARLES TWINING, ESQ., Halifax ; and C. C. JAMES, ESQ., Deputy Minister of Agriculture, Toronto.

PROFESSOR E. E. PRINCE, Commissioner and General Inspector of Fisheries for Canada, delivered a lecture on "Recent Discoveries regarding the Eggs and Young of Fishes." The lecture was illustrated by a number of lantern views.

Remarks upon the subject were made by DRS. REID, MACKAY, SOMERS, and MURPHY, and also by the Chief Game Commissioner, C. S. HARRINGTON, ESQ., Q. C.

Third Ordinary Meeting.

Legislative Council Chamber, Halifax, 11th January, 1897.

The First Vice-President, Mr. McKay, in the chair.

The Secretary announced that Professor E. E. Prince, Commissioner and General Inspector of Fisheries for Canada, Ottawa, had been elected a Corresponding Member.

Professor J. G. MacGregor, D. Sc., presented a paper "On the Relations of the Physical Properties of Solutions to their State of Ionization," second part. (See Transactions, p. 219).

The subject was discussed by Professor E. MacKay and Mr. J. Forbes.

Fourth Ordinary Meeting.

Provincial Museum, Halifax, 8th February, 1897.

The Second Vice-President, Dr. MacKay, in the chair.

Rev. Brother Peter, of La Salle Academy, exhibited a number of Dried Plants, which he had collected in the vicinity of Halifax, and made remarks thereon.

In the absence of the author, a paper entitled, "Measurements of two Beothuk Skulls," by W. H. Prest, Esq., was read by the Secretary :—

"Having been asked to give the measurements of two Beothuk skulls taken while at the Museum at St. John's, Newfoundland, I submit the following :

In order to more fully explain these measurements. I may say that the term brachy-cephalic, or round-headed, is used to denote skull forms where the proportion of the breadth to the length is as 80 and upwards to 100. The term dolicho-cephalic, or long-headed, denotes proportions of from 75 and downward to 100. All intermediate proportions are termed meso-cephalic.

No. 1. Adult skull marked No. 6 in the St. John's Museum Collection:

	Inches.
Glabella to occipital point	7.425
Greatest width of skull	5.825
Bregma to occipital condyle	6.075
Resulting index, meso-cephalic	78.45

No. 2. Adult Female (?):

	Inches.
Glabella to occipital point	6.825
Greatest width of skull	5.600
Bregma to occipital condyle	5.700
Resulting index, brachy-cephalic verging on meso-cephalic	80.20

The measurements in the above instances, although taken without any very elaborate instruments, can not be in error more than $\frac{1}{80}$ of an inch. Another skull and skeleton, almost perfect, want of time prevented me from measuring. It, however, showed features of a decidedly lower type than the others, particularly in the enormous supercilliary ridges and narrow retreating forehead. The nose was extremely aquiline, as were those of the other skulls. It appears to approach the long-headed type more nearly than the others, but measurements of such a limited number of skulls cannot be considered as settling or even approximating the question of tribal index. Our chief hope, therefore, lies in the expectation of future explorations of Beothuk burying grounds. That the above skulls are genuine Beothuk remains, I give as authority Mr. Howley, Director of the Geological Survey of Newfoundland, through whose care all the relics of this interesting race are preserved. For further evidence as to their authenticity, I would give the name of Rev. M. Harvey, who discovered skull No. 1 at Pilley's Island, Notre Dame Bay, Newfoundland, under circumstances which leave no doubt that it was Beothuk.

Another Beothuk skull, which I do not think has been measured, is to be seen at McGill University, Montreal. It was found in 1847 by Rev. Mr. Blackmore, Rural Dean of Conception Bay, on a small island called Rencontre, one of the Lower Burgeo group, on the southern coast of Newfoundland.

In order to show more fully the position the Beothuks occupied in North America, I may say that the Indians are brachy-cephalic while the Esquimaux are dolicho-cephalic. These are the nearest races the

boundaries between which lie in the neighbourhood of that part of Labrador nearest Newfoundland. The long-headed races seem to have belonged to an ancient type inferior as a rule to their round-headed brethren. And since paleolithic times they have been gradually pushed to the outlying parts of the earth. Therefore, the occurrence of an apparently intermediate form in Newfoundland is what we might expect from its position near the junction of two such different types."

The preceding notes are given in the hope that they may lead to systematic investigation of this now extinct race by some one more competent than myself. I am more desirous of this, as I have made a mistake in taking measurements for the vertical index from the bregma to the occipital condyle instead of to the basion. Scarcely within modern times has it been that a tribe has been so completely annihilated that even of its language hardly a remnant remains. The story of the persecution and slaughter of the Beothuks by the white man is a sad one. The history of Newfoundland contains a page—marked with blood and darkened with disgrace—a page that tells of inhuman slaughter and cruelty that makes the blood of every true man boil—the ruthless extermination of a harmless and despairing race."

A number of interesting remarks upon the subject were made by REV. DR. PATTERSON, of New Glasgow.

CHARLES TWINING, ESQ., then gave an account of some "New Arrangements in Sailing Gear." The subject was discussed by a number of those present.

FIFTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 8th March, 1897.

The Second Vice-President, DR. MACKAY, in the chair.

It was announced that JAMES FLETCHER, ESQ., LL.D., F. R. S. C., F. L. S., Entomologist and Botanist, Central Experimental Farm, Ottawa, had been elected a Corresponding Member.

MR. PIERS was appointed delegate to represent the Institute at the June meeting of the Royal Society of Canada.

A paper by DR. GILPIN, on "Some Analyses of Nova Scotia Coals and other Minerals," was read by DR. MACKAY in the absence of the author. (See Transactions, p. 246).

SIXTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 12th April, 1897.

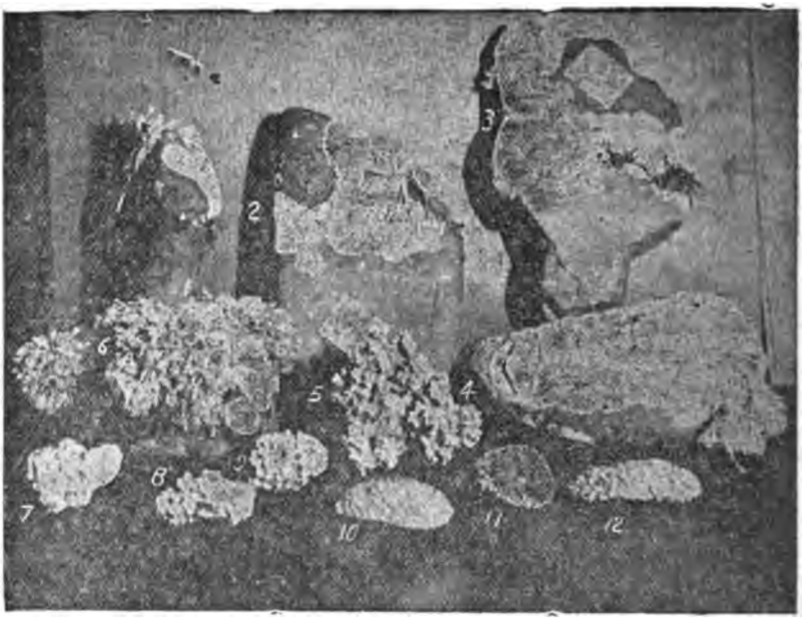
The PRESIDENT in the chair.

A communication was read from the Royal Society of London announcing that at a recent meeting of that body it had been unanimously resolved that a fund, to be called the Victoria Research Fund, be established, to be administered by representatives of the various scientific societies, for the encouragement of research in all branches of science. The Society wished to know if the scheme met with the approval of the Institute.

Resolved, That this Institute, having heard the communication of the 22nd February, addressed to its President by the President of the Royal Society of London, in reference to the proposal to establish a Research Fund in commemoratian of the present sixtieth year of the reign of Her Gracious Majesty the Queen, express its cordial approval of the proposal.

Resolved, further, That while the Institute is of opinion that no large contribution to the proposed fund can be expected from the Province of Nova Scotia, whose men of science are few, and whose industries have not yet reached the stage in which the advantages of scientific research become manifest, the Institute will be glad to co-operate with other scientific societies in Canada in bringing the claims of the proposed fund to the notice both of their members and of other citizens who may be expected to become contributors.

Calcareous Algæ.



(Reduced to nearly one-fifth of actual diameter).

Dr. A. H. MacKay presented specimens of calcareous algæ for general examination, such as the incrustations shown on the stones at 1, 2, 3, 4, and 6 (above), which came from low water at Cranberry Head, near Yarmouth. Tufts of *Corallina officinalis*, L. were growing conspicuously from some parts of these; 5, 7, 8, 9 and 11 were more or less tuberculose or branching incrustations of *Lithothamnion* on stones as a base, while 10 and 12 were incrusting mussel shells. His discussion of the group was preliminary to further work, and the exhibition of the specimens was to enlist the fellowship of additional collectors of these species. The *Corallineæ*, or calcareous algæ, which he was showing, came principally from Point Pleasant, within and opposite the mouth of Halifax harbor, although he had specimens all the way from Brier Island to Cape Breton. The *Corallineæ* belonged to the *Florideæ*, or red sea-weeds.

The genus *Corallina* grows in feather-like tufts composed of short articulations when examined closely. When growing, these fronds are of a darkish or light red color like that of the *dulse* and other red algæ.

They are soon bleached white by exposure to light, and after being dried become very brittle, the articulations falling apart. In addition to the red coloring matter there is a large amount of lime laid up with the tissue of each articulation, so that we have here plants which secrete lime from the sea water as the coral does among animals. Dilute hydrochloric acid applied to a portion of one of these fronds well covered with glass to protect the microscope, will show under a low power a rapid evolution of carbonic acid gas until the articulations of the frond become translucent, when all the lime is dissolved out of the vegetable tissue.

The genus *Melobesia* appears as small, thin, more or less circular incrustations of lime filled tissue on other algæ, generally. Thin incrustations on stones taken for *Melobesia Lenormandii* of Farlow are, probably, forms of *Lithothamnion compactum.*

The genus *Lithothamnion* forms larger incrustations, of a red or purple color before they are bleached, some of the species rising into minute nodules or tubercles, and others rising even into rudely branching coral-like masses. The name, from *lithos* a stone and *thamnion* a little bush, was suggested by the latter habit. The reproductive organs of all these are in conceptacles, small spherical cavities, either immersed in the general frond or rising out of it. They are difficult to section for microscopic examination, for if the calcium carbonate is dissolved out of the tissue by, say, dilute hydrochloric acid, no matter how gently it is done, the tissue is more or less disorganized so as not to show the minute parts distinctly. And the sectioning of the undecalcified plants is very severe on the razor or other cutting apparatus.

The two species of Farlow's Marine Algæ of New England, *L. polymorphum* and *L. fasiculatum,* the tubercular or lobular, and the branching species respectively, 5 above being the most distinctive of the latter, are found all along the coast. But from the studies of M. Foslie, of Trondhjem, Norway, these two general forms may be found to cover several distinct species. Probably the following more exact species are represented under these forms :—

Lithothamnion fruticulosum, (Kutz.) Foslie, f. *typica,* Foslie, the most conspicuous branching form. Next to it comes

L. colliculosum, Foslie. Then comes

L. glaciale, Kellm.

L. compactum, Kellm. And possibly,

L. conscriptum.

As these algæ have been very little studied hitherto, he hoped those having an opportunity to collect specimens, or who could get specimens which might be brought up in fishermen's nets, would bring them to the Museum of the Institute.

DR. SOMERS made some remarks on the subject.

HARRY PIERS, ESQ., then read a paper entitled, "Notes on Nova Scotian Zoology: No. 4." (See Transactions, p. 255).

The paper was discussed by DR. SOMERS, MR. BISHOP, and DR. REID.

SEVENTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 10th May, 1897.

The First Vice-President, MR. MCKAY, in the chair.

A paper entitled, "A Supplementary Note on Venus," by PRINCIPAL CAMERON, of Yarmouth Academy, was read by DR. MACKAY. (See Transactions, p. 275).

The paper was discussed by DR. REID and the CHAIRMAN.

A. H. MACKAY, ESQ., LL. D., F. R. S. C., read a paper entitled, "Phenological Observations for 1896." (See Transactions, p. 268).

The subject was discussed by PROFESSOR MACGREGOR and the CHAIRMAN.

A paper on the "Rainfall of 1896," was then read by MR. DOANE. (See Transactions, p. 279).

DR. MURPHY, DR. MACKAY, and others, took part in the discussion which followed.

The following papers were then read by title:—

"On the Tides of the Bay of Fundy" (second paper). By MARTIN MURPHY, ESQ., D. Sc., Provincial Engineer.

"On the Water Supply of the Towns of Nova Scotia." By PROBESSOR W. R. BUTLER, M. E., King's College, Windsor.

HARRY PIERS,
Recording Secretary.

MEMBERS of the Institute, and Societies in correspondence with it, would confer a great favor if they would send to the Council, for distribution to Scientific Institutions whose sets of the Institute's publications are incomplete, any duplicate or other spare copies which they may possess of back numbers of its Proceedings and Transactions. They should be addressed *The Secretary of the N. S. Institute of Science, Halifax, Nova Scotia.*

THE attention of members of the Institute is directed to the following recommendations of the Committee of the British Association on Zoological Bibliography and Publication :—

"That author's separate copies should not be distributed privately before the paper has been published in the regular manner

"That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible.

"That new species should be properly diagnosed and figured when possible.

"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules for quotation, such as that recently adopted by the French Zoological Society."

THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science,

HALIFAX, NOVA SCOTIA.

VOLUME IX

(BEING VOLUME II OF THE SECOND SERIES.)

PART 4.

SESSION OF 1897-98.

WITH A PORTRAIT, ONE PLATE, AND THE INDEX, TITLE PAGE AND TABLE OF CONTENTS OF VOL. IX.

The First Series consisted of the Seven Volumes of the Proceedings and Transactions of the Nova Scotian Institute of Natural Science.

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George Patterson

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1897-98.

Annual Business Meeting.

Legislative Council Chamber, Halifax, 8th November, 1897.

The President, Dr. Gilpin, in the chair:—

The President addressed the Institute, as follows:—

"Gentlemen,—I have much pleasure in opening another session of the Institute, and trust that our meetings will be successful and our papers more numerous. We have held our own in numbers, and have maintained our position among our sister societies.

The Institute had recently to mourn the removal, by death, of our friend and President, Dr. Lawson, and we have now to deplore the loss from our ranks of Rev. Dr. Patterson. It is true that he was not as intimately and directly connected with our work as Dr. Lawson. This, however, was our loss, for he had eminently the Academician mind, and, had his other pursuits permitted, his services to the Institute would have been both great and distinguished. His thirst after knowledge, his assiduity in collecting facts, his faculty of assimilation, would, if directed specially to any of the objects of the Institute, have given him a most cherished position among us.

George Patterson was born in Pictou, April 30th, 1824, and, on his mother's side, was a grandson of the Reverend Doctor McGregor, a name famous in the annals of Presbyterianism in Pictou County. What Pictou County in particular, and generally the Province, owe him has

been well told by his grandson, the subject of these remarks. His boyish education was received at Pictou in a school noted for inculcating thoroughness and perseveranee as the foundation stones of scholarship. He completed his academic studies at Dalhousie College, and removing to Edinburgh, studied theology at the United Presbyterian Theological Hall.

Returning to his native land, he entered upon his clerical duties at Greenhill, in the County of Pictou, and ministered to his congregation until 1879, when he resigned his charge and removed to New Glasgow. Assiduous and gentle, while upholding firmly the doctrines of his Church, his consistent discharge of his parochial duties endeared him to all who looked up to him as a spiritual guide.

To the general public, however, he was best known as a biographer and historian. At the age of nineteen, in the year 1843, he established and edited the *Eastern Chronicle*. This paper is still published, and is one of the most influential of our Provincial weeklies.

In 1850, he became editor of the *Missionary Record* of the Presbyterian Church in Nova Scotia, a periodical which, after passing through several changes, is now known to us as the *Presbyterian Record*. During his association with the organ of his church, he was outspoken in support of the better moral life of the people, and especially urged the duty of missionary work.

It is impossible for me to give here details of his writings. I may mention the "Life and Labors of Dr. Keir," "Memoir of Rev. Dr. McGregor," two histories of Pictou County. Princeton University conferred on him the degree of Doctor of Divinity, in recognition of the ability he displayed in his only theological work on the "Doctrine of the Trinity underlying the Revelation of Redemption," published in 1870.

As a contributor to the literature of missions, in addition to numerous newspaper and magazine articles, he published, in 1864, the "Memoirs of Johnstone and Matheson;" in 1882, the "Life of the Reverend John Geddie," and in 1884, an essay on missions called "The Heathen World."

In 1889 Dr. Patterson was elected a fellow of the Royal Society of Canada, and in 1896 Dalhousie University conferred on him the degree of Doctor of Laws. This degree was fittingly conferred on one of her oldest students who gave the good fruit of a mind which retained and adorned the education of its Alma Mater.

I am informed that ever active and industrious, he had recently completed a History of the Fathers of the Presbyterian Church in Nova Scotia.

Dr. Patterson's work in science was subsidiary to his historical labors, and necessarily lessened in amount. He was naturally interested in Archæology, and in this respect conferred a favor on the Province by making a large collection of articles illustrating the life of our Indians in pre historic days. He presented this valuable collection to Dalhousie College, where it is available to all students of the subject, and described it in a paper read before the Institute.

As a historian his attention was naturally drawn to the alterations which languages have undergone in consequence of changes of environment. On this subject he published papers in the Transactions of the American Folk Lore Society, of the Royal Society of Canada, and in our Proceedings. We owe to his historical interest not only the valuable historical papers published in the Transactions of the Royal Society of Canada, and the Nova Scotia Historical Society, but also such ethnological papers as "The Beothiks," published by the Royal Society, and geographical papers such as "The Magdalen Islands," in our Transactions, and "Sable Island," in those of the Royal Society.

A full list of his publications down to 1894 may be found in the Transactions of the Royal Society for that year, and a list of his subsequent papers will probably be published by the same Society.

Dr. Patterson was noted for his diligence in collecting facts, and for the amount of research he expended on every subject he took up.

Few for instance, who read a history of one of our counties, realize that these annals of recent times require an enormous amount of work in collection of data, and nearly as much more in the separation and accretion of the essential. Similarly his Folk Lore papers gave evidence of most minute and painstaking enquiry.

Scholarly in his sermons, keen and tenacious in his editorial work, painstaking in his researches and polished in his writings, he has shown what can be done by the student, even when confined by fate to an outlying district of the literary and scholastic world. His example is a good one for all to follow, if not to surpass; and his work in its way was performed precisely as our work as members of the Institute of Science should be performed, that is by patient enquiry and research, followed

by prompt publication, for facts known to the individual are buried unless made public.

As Dr. Patterson died during the recess of the Institute, I took upon myself as expressing the feelings of the members to request the Corresponding Secretary to convey to the family of the deceased our sympathy with them in their loss, and asked him to represent the Institute at the funeral.

Among the events of interest to the Institute last year may be mentioned the visit of the Royal Society. They left, as a memento, the handsome tablet on the walls of this Chamber, commemorating the landfall of Cabot. The result of impartial investigations leads to an apparently well founded belief that the history of English domain on this continent had its opening page on the romantic shores of Cape Breton.

The Provincial Exhibition, from the standpoint of this Institute, was remarkable for what it did not exhibit. Advantage should be taken of such occasions by the Provincial Government to teach people something new and practically valuable. Each year some subject should be taken up and illustrated. A display of insects injurious to the farmer or fruit-grower, giving their life history, changes, food, etc., and the remedies would serve for a number of teaching exhibits. In a similar manner the subject of soils, fertilizers, etc. The more advanced systems of fishing, curing fish, etc., in other countries. Every one can add to this list. I believe that the Provincial Government would find their efforts in these directions well appreciated, and the material in many instances would be permanently available for their agricultural schools and for museums. This matter may be worth your consideration, and you may see an opportunity to offer assistance to the Government in preparing and advancing such exhibits.

These remarks on the Provincial Exhibition of a few days lead our thoughts to our permanent Provincial Exhibition, the Museum. It may be the case that Nova Scotians as a body retain the old fashioned idea that a museum should be a collection of curiosities. If so, it is the duty of the Institute to educate them to a better understanding. As you are aware, several representations have been made to the Government as to the importance of a modern museum, and its value from an educational as well as an economic standpoint. I think that the necessity of action has been conceded by the Government, but the provision from a fixed revenue for ever increasing public wants renders it difficult to provide funds for a new building.

As a preparation for the new state of affairs, which must come, and as a means of partly meeting the present want, it has been suggested that the collections should be reorganised.

The establishment of a museum, taking the word in its wide and proper sense, is an expensive undertaking beyond the means of a Provincial Government. In our position a much more limited definition of the word would be most useful and cost but little. If the Museum were restricted to the collection and exhibition of material purely Provincial, it would be valuable and practically without cost. A museum, illustrating the natural resources of the Province, of the ocean, the woods, the soil, the minerals, and the manufactures depending on them, would be a credit to the country and city, and of untold interest and value to visitors and capitalists who could see at a glance what we had to offer. A scheme such as this should meet general approval, and still better could be made at a very small cost.

There is in the Museum much material which, interesting in itself, is of little scientific or teaching value, as it is incomplete This could be given or traded with other institutions for material needed for completing or supplementing local collections. I know, as a matter of fact, that there are numbers of people in the Province who would be ready to contribute to a practical exposition of our resources as outlined above.

Some slight work has been done in the way of re-arranging and labeling the more important collections, but they have been seriously drawn upon for various foreign exhibitions, and require renewal. The Mining Society of Nova Scotia has already taken an interest in this matter conjointly with the Institute, and these two bodies may see their way to effect improvements in addition to those already made.

The following papers have been communicated to the Institute during the past year :—

Two papers by Professor McGregor on the Relation of the Physical Properties of Solutions to their State of Ionization.

Recent discoveries regarding the young and eggs of fishes, by Dominion Fishery Commissioner Prince.

The botany of the vicinity of Halifax, by Rev. Brother Peter.

Measurements of two Beothuk skulls by Mr. W. H. Prest.

New arrangements in sailing gear, by Charles Twining.

Some analyses of Nova Scotia coals and minerals, by the President.

Notes on Calcareous Algæ, by Dr. MacKay, and by Mr. Harry Piers on Nova Scotia Zoology.

Supplementary note on Venus, by Principal Cameron.

Phenological observations by Dr. MacKay, and Rainfall of 1896 by City Engineer Doane.

At the last meeting two papers were read by title, one by Dr. Murphy on the tides of the Bay of Fundy, and one by Professor Butler on the water supply of Nova Scotia towns. Dr. Murphy has promised to complete his paper during the present session, and, no doubt, Professor Butler will have his paper completed shortly. I may remark that he has left King's College, Windsor, to fill the chair of mathematics at the Military College, Kingston.

During the past year we have continued to add to our valuable library, fuller details of which can be given by the Librarian. A large number of the exchanges have been arranged and placed in bindings, plain, but strong and serviceable. Through the kindness of the authorities of Dalhousie College we have been allowed the use of a room fitted with shelving, etc., so that the more important of our exchanges are readily accessible for reference and study."

The Treasurer's report was presented, together with his accounts for the year, which had been audited and certified as correct, and an abstract of the accounts shewing the amounts expended on Library, publication of Transactions, distribution of Transactions, etc. The report was adopted and the thanks of the Institute tendered to Mr. Silver for his services as Treasurer.

The report on the Library was presented by Dr. McGregor. It showed that exchanges had been received for the first time during the past year from the following:—

The Museum, Albion, N. Y.

N. E. Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne.

Royal Geographical Society of Australasia, Sydney, N. S. W.

Academia Mexicana de Ciencias exactas Fisicas y Naturales, Mexico.

Appalachian Mountain Club, Boston.

Die Niederrheinische Gesellschaft fiir Natur-u. Heil-kunde, Bonn.

Nuttall Ornithological Club, Cambridge, Mass.

Société Hongroise de Geographie, Buda-Pest.

Accademia di Scienze Lettere e Arti, Acireale, Italy.

Direccion General de Correos y Telegrafos, Buenos Aires.
Premiere Exposicion Centro-americana de Guatemala, San Josè.
Société Neuchateloise de Geographie, Neuchatel.
Faculté des Sciences de Marseille.
Physikalische Gesellschaft, Berlin.
Geological Society of Washington.
Kansas University, Lawrence, Kan.
Australasian Anthropological Society, Sydney, N. S. W.
Pennsylvania State College (Agricultural Experiment Station).
Geological Survey of Java and Madoura.
Sydney Observatory, Sydney, N. S. W.
Société Entomologique, Bruxelles.
R. Orto Botanico di Palermo.
Bureau General de Statistique, La Plata.
Instituto Geologico de Mexico, Mexico.
Historischer Verein für Oberpfalz und Regensburg, Regensburg.

Copies of the Transactions had been sent for the first time to the following :—

Nuttall Ornithological Club, Cambridge, Mass.
Faculté des Sciences, Marseille.
New York Electrical Society, New York.
New York Public Library.
Physikalisches Central Observatorium, St. Petersburg.

Exchange relations which had been previously established with other Societies had, in no case, been terminated, and in consequence, the Library was growing rapidly.

Partly through lack of time on the part of the Library Committee, and partly through the difficulty of getting at the books owing to the crowded state of the cases, no books had been bound during the year. The money which was available for that purpose had therefore been carried forward to next year's account, and would be expended as soon as possible.

The English, Scottish, Irish and American publications were in the Institute's cases on the third floor of the Post Office building ; all other publications at Dalhousie College. The cases at the Post Office were excessively crowded, insomuch that it was practically impossible to obtain access to books that were wanted. In these circumstances the

council had gladly availed themselves of an offer courteously made by the Governors of Dalhousie College to provide temporary accommodation for the whole Library at the College in a room already fitted with shelving. At the present rate of growth of the Library, the accommodation thus offered would probably be sufficient for the needs of the Institute for from eight to ten years, and the necessity of acquiring rooms of our own would thus be postponed for that period of time. The work of removing and re-arranging the books would be proceeded with as soon as possible. When completed, the Library would be much more readily accessible to members than it had ever been in the past.

The report was adopted, and the thanks of the Institute tendered to Mr. Bowman and Prof. MacGregor for their work in connection with the Library.

It was resolved that the council be instructed to a make minute of the loss sustained by the Society in the death of REV. DR. PATTERSON. Also resolved, that a portrait of the deceased be published in the Proceedings and Transactions.

The thanks of the Institute were presented to the retiring PRESIDENT, DR. GILPIN ; to the GOVERNORS OF DALHOUSIE COLLEGE for their courtesy in providing accommodation for the Institute's Library ; to the HON. ROBERT BOAK, President of the Legislative Council, for granting the use of the Council Chamber ; and to the Secretary of the SMITHSONIAN INSTITUTION, Washington, for continuing to extend to the Institute the privileges of the Bureau of International Exchanges.

The following officers were elected for the ensuing year (1897-98):—

President—ALEXANDER MCKAY, ESQ.

Vice-Presidents—A. H. MACKAY, ESQ., LL.D., F.R.S.C., and F. W. W. DOANE, ESQ., C. E.

Treasurer—W. C. SILVER, ESQ.

Corresponding Secretary—PROF. J. G. MACGREGOR, D. SC.

Recording Secretary—HARRY PIERS, ESQ.

Librarian—MAYNARD BOWMAN, ESQ.

Councillors without office—E. GILPIN, ESQ., LL.D., F.R.S.C. ; MARTIN MURPHY, ESQ., D. SC. ; WILLIAM MCKERRON, ESQ. ; RODERICK MCCOLL, ESQ., C. E. ; REV. BROTHER PETER ; S. A. MORTON, ESQ., M. A. ; WATSON L. BISHOP, ESQ.

Auditors—P. O'HEARN, ESQ. ; G. W. T. IRVING, ESQ.

First Ordinary Meeting.

Legislative Council Chamber, Halifax, 8th November, 1897.

The President, Mr. McKay, in the chair.

The Secretary announced that Dr. W. Henry Dobie, of Chester, England, had been elected a Corresponding Member of the Institute.

A paper "On the Calculation of the Conductivity of Aqueous Solutions containing Potassium and Sodium Sulphates," by E. H Archibald, Esq., Physical Laboratory, Dalhousie College, was read by Dr. MacGregor. (See Transactions, p. 291).

Second Ordinary Meeting.

Legislative Council Chamber, 13th December, 1897.

The President in the chair.

It was announced that R. R. McLeod, Esq., of Brookfield, N. S., had been elected an Associate Member.

Dr. MacGregor, Corresponding Secretary, laid before the Institute an invitation to attend the Centenary of the Hanover Geological Society.

Dr. MacGregor also reported progress in removing the Library to Dalhousie College.

E. H. Archibald, Esq., Physical Laboratory, Dalhousie College, read a paper "On the Relation of the Physical Properties of Certain Complex Solutions to their state of Ionization." (See Transactions, p. 335).

The paper was discussed by Dr. MacGregor and Prof. E. MacKay.

The thanks of the meeting were conveyed to Mr. Archibald.

A paper on "Glacial Clays in New Jersey, with correlation of them elsewhere," by Arthur M. Edwards, Esq., M. D., of Newark, N. J., was read by Dr. Gilpin.

Third Ordinary Meeting.

Council Chamber, City Hall, Halifax, 21st February, 1898.

The President in the chair.

E. H Archibald, Esq., B. Sc., read a paper "On the Calculation of the Conductivity of Solutions containing Potassium-Copper Sulphate." (See Transactiont, p. 307).

The paper was discussed by Drs. MacGregor and MacKay.

Dr. MacGregor then delivered an address on "Physical Laboratory Work of an Elementary Grade."

The address was discussed by Prof. E. MacKay, Dr. A. H. MacKay, and Messrs. Morton, O'Hearn, Trefry and Marshall.

Fourth Ordinary Meeting.

Legislative Council Chamber, Halifax, 14th March, 1898.

The President in the chair.

The President referred to the loss the Society had sustained in the death of Dr. Somers, who had for several years been President of the Institute, and who had contributed a number of papers to its Transactions.

On motion, the President, the Recording Secretary, and Dr. MacKay, were appointed a committee to draw up a resolution of condolence and to forward the same to Mrs. Somers.

Charles Twining, Esq., exhibited a working model of a "Pivot-Boat," and explained the principles upon which it was constructed.

The subject was discussed by Drs. MacKay, Murphy and MacGregor, and Mr. Stayner.

T. C. McKay, Esq., B. A., of Dalhousie College, read a paper "On the Electrical Conductivity and other Properties of Solutions containing Barium and Sodium Chlorides." (See Transactions, p. 321.)

The paper was discussed by DR. MACGREGOR; and the thanks of the Society were presented to the author.

The following paper was read by title :—" On the Calculation of the Conductivity of Solutions containing Potassium-Magnesium Sulphate." By T. C. MCKAY, ESQ., B. A., Dalhousie College. (See Transactions, p. 348).

FIFTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 9th May, 1898.

The PRESIDENT in the chair.

A paper on "The Triassic (?) Rocks of Digby Basin," by PROFESSOR L. W. BAILEY, LL. D., Ph. D., F.R.C.S., of the University of New Brunswick, was read. (See Transactions, p. 356).

A. H. MACKAY, ESQ., LL. D., F.R.S.C., presented a "Plan of a Proposed Ethnological Survey of Canada."

DR. MACKAY also read a paper entitled : " Phenological Observations for 1897." (See Transactions, p. 402).

The following papers were read by title :—

Flora of Newfoundland, Labrador, St. Pierre et Miquelon : Part III —By REV. ARTHUR C. WAGHORNE, Newfoundland. (See Transactions, p. 361).

On the State of Ionization of Simple and Complex Solutions, at 0°C., as determined by Freezing-point and Conductivity Methods.—By E. H. ARCHIBALD, ESQ., M. Sc.

The PRESIDENT, and MESSRS. SILVER and PIERS, were appointed a committee to wait upon the Government of Nova Scotia for the purpose of recommending the purchase, for the Provincial Museum, of the Indian stone implements in the collection of JUDGE DESBRISAY.

On motion, the council was authorized to receive as read by title, any papers that may be presented too late for this meeting.

HARRY PIERS,
Recording Secretary.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1894-95.

I.—NOTES ON CONCRETIONS FOUND IN CANADIAN ROCKS.—BY T. C. WESTON, F. G. S. A., LATE OF THE GEOLOGICAL SURVEY OF CANADA.

(Read 14th January, 1895).

Every student of geology is familiar with concretionary matter. I purpose in this short paper giving descriptions and illustrations of a few of the more interesting forms.

The resemblance of many concretions found at various horizons of our Canadian rocks, to some of the Monticuliporidæ and Stromatopora of the Trenton, Chazy and other formations has often caused them to be mistaken for these fossils. Notes by the writer in Trans. of the Nova Scotian Inst. of Science. Ser. 2, Vol. 1, Fig. 1, reproduced supposed *Oldhamia* of the Huronian Rocks of Newfoundland.

FIG. 1.

Concretions are most commonly spheroidal, or nearly so in shape, and range in size from that of a grain of sand to twenty and thirty feet in diameter.

1. On the coast of Arisaig, N. S, in the argillaceous slates and shales of the Clinton formation, slightly flattened spheroidal forms are abundant. Two of these, about two feet in diameter when broken through the centre, showed no concentric layers or nuclei, while many others, varying in size from the eighth of an inch to two inches in diameter, contained invariably a nucleus; sometimes a grain of sand, but generally the brachiopod, *Lingula oblonga*, Hall.

2. The largest concretions seen by the writer were found in the Fox Hill and Pierre shales and clays of the North-West, and a very interesting exhibition of giant forms may be seen three miles north of Irving station-house on the Canadian Pacific Railway. Here, huge boulder-like spheroidal and ovoid concretions once held in the rocks but removed by great denudation (probably in the glacial epoch, for glacial striæ are seen on some of the flat beds), stand out in bold relief, resting on the flat and upturned edges of shales and sandstones; and on the top of one of them, about twenty feet high, an eagle had built its nest of buffalo-bones and the roots of the wild sage, for want of a more elevated situation, which does not occur in this locality.

In composition they appear to be chiefly argillaceous and calcareous sandstones. Many of them have fallen to pieces, and the debris shows that they have been formed in layers which increased in thickness from the centre outward. Portions of the beds from which they were derived were found enclosed in several of them, and the stratified pieces of the bed-rock were found to be prolific in fossils. Among the genera and species found in these were: *Lingula nitida; Protocardia subquadrata; Liopistha undata, etc.*

3. Mr. R. G. McConnell, of the Geological Survey, describes

similar concretions in a Cretaceous rock of Grand Rapids, Athabasca River*, as follows:—

"It is remarkable for the large number of spheroidal siliceous concretions which it contains, and which range in size up to ten feet or more in diameter. No fossils were found in the concretions or in the rocks which hold them."

The same agency which produced these great concretions no doubt formed the smaller pipe-stem concretions, so numerous in the Miocene rocks at the head waters of Swift Current, N. W. T., and which are now being formed on the shores of Lake Champlain.

4. Another interesting concretion locality lies half a mile west of White Mud River, near the Fort Walsh trail, in the Assiniboine district, N. W. T., the rocks belonging to the Laramie formation. Here a small butte was pointed out to me by my half-breed Indian guide, who called the place gun-shot butte, and said a few years ago when he, with others, hunted buffalo in that locality, they sometimes, when ammunition was scarce, used these "balls" in their guns and rifles. I found the hill, or butte, to consist largely of calcareous sand, which contained enormous quantities of spheroidal concretions, varying in size from that of buck-shot to an inch in diameter; the ordinary size being that of rifle balls. A great number of these are compound forms representing two halves of a sphere coalescing together, sometimes a number of these marbles (as the Indians call them), are clustered together into pieces as large as one's head. They are all more or less covered with nodes. About one-third of each is carbonate of lime, which dissolves out with muriatic acid, leaving a residue (as seen under the microscope), of grains of pure silex, with a few of feldspar, magnetite, and mica. There are no concentrie layers and no nuclei.

5. The Animikie argentiferous rocks of the Thunder Bay district are remarkable for "bombs," so called by the miners. At the Beaver silver mine, a few miles from Port Arthur, many concretions resembling cannon balls may be seen in the black carbonaceous slates which are largely developed at this locality.

* Geological Survey Report for 1889-90-91.

They appear to be composed of cherty argillite, and are slightly calcareous, and some when broken through the centre show concentric layers, chiefly of pyrites. No distinct radiating structure, and no nuclei were seen in any of the specimens broken.

6. In the Devonian rocks of Kettle Point, in Bosanquet, on Lake Huron, forms similar to the foregoing in outward appearance exhibit different internal structure. They are described in the Geology of Canada, 1863, p. p. 387-88, as: "Peculiar spheroidal concretions whose fancied resemblance to inverted kettles has probably given its name to the point. They vary in size from three inches to as many feet, and are sometimes nearly spherical, and others sometimes flattened, generally on the under side. Occasionally a smaller spheroidal mass is implanted on the top of a larger one. These concretions are readily broken, and are then seen to be composed of brown crystalline carbonate of lime, which is confusedly aggregated in the centre, and sometimes contains blende. Around this are arranged slender prismatic crystals which extend from the nucleus to the circumference; the whole having a radiating columnar structure, which, not less than the terminations of the prisms, at the surface of the spheroidal masses, gives them very much the aspect of fossil corals"

7. The Upper Devonian fish and plant bearing beds of Scaumenac Bay, New Brunswick, are prolific in fossiliferous concretions, which are composed of calcareo-arenaceous rock, and take various forms according to the shape of the nucleus, which is often so well preserved that every bone can be seen. One of these concretions obtained by A. H. Foord measures over twenty-one inches in length, and contains the skeleton of a fish almost as long. It is *Chirolepis Canadensis* (Whiteaves). In other concretions from this locality the writer and Mr. A. H. Foord found: *Glyptolepis microlepidotus* (Agassiz), *Phaneropleuron curtum*, *Pterichthys Canadensis* (Whiteaves), *Eusthenopteron Foordi*, *etc.*

In the coal bearing rocks of Skidegate Inlet of the Queen Charlotte Islands, concretionary nodules are found, in which

Ammonites and crustaceans occur. Among these are Ammonites (Desmoceras), Sacya (Forbes), and Ammonites (Haploceras), Beudanti, Brongniart.

8. The Huronian rocks, which I have described above, Fig. 1, contain many curious concretions. Some of the small islands in Georgian Bay are composed of a calcareous greenstone, in which an aggregate of quartz, feldspar, chlorite, epidote, etc., are found. In this rock concretionary balls an inch in diameter occur, microscopic sections of which show them to be composed of the same material as the matrix in which they are imbedded, both being highly crystalline, and the concretions having a scoriated appearance.

9. A soft, whitish limestone from the Cambrian deposits of Cow Head, Newfoundland, is composed chiefly of rounded grains of irregular shape and size, many of which might readily be taken for Ostracod crustaceans, or have a close resemblance to the species *Conodona Tateana.* The microscope, however, shows them to be concretious, generally partly hollow and filled with crystalline limestone. In the beds from which the specimens examined came, ten species of trilobites have been found by Dr. Ami of the Geological Survey of Canada.

10. An oolitic limestone from the Cambrian rocks of the Selkirks, B. C., two miles west of Donald, shows under the microscope concentric layers, slight radiating lines and crystalline fibres arranged at various angles transverse to the concentric structure. Fig. 2 is from a micro-drawing of one of these forms, enlarged about 20 diameters.

FIG. 2.

11. In Cape Breton, and at Arisaig, N. S., there are bands of limestone composed entirely of concretions no larger than mustard seeds, and sometimes much smaller. They represent our oolitic rocks. Those of Cape Breton belong to the carboniferous formation, and those of Arisaig are associated with the lower carboniferous conglomerates and sandstones of the coast rocks. In my notes of 1873 of a portion of the Arisaig rocks, I wrote: "At Grant and McDonald's Cove the sandstones are in contact with a band of light gray limestone (Photo. No. 18), resting on six feet of bluish gray calcareous shale, holding a *Lingula* and two small bivalves resembling *Modiolopsis*, but not determinable with certainty. In the limestones of which there is a thickness of about twenty feet, I found two species of *Rhynchonella* and one *Athyris*. A great part of this limestone is oolitic, or made up of minute concretions." Fig. 3 is a microdrawing from a thin slice of the Cape Breton limestone magnified about twenty times.

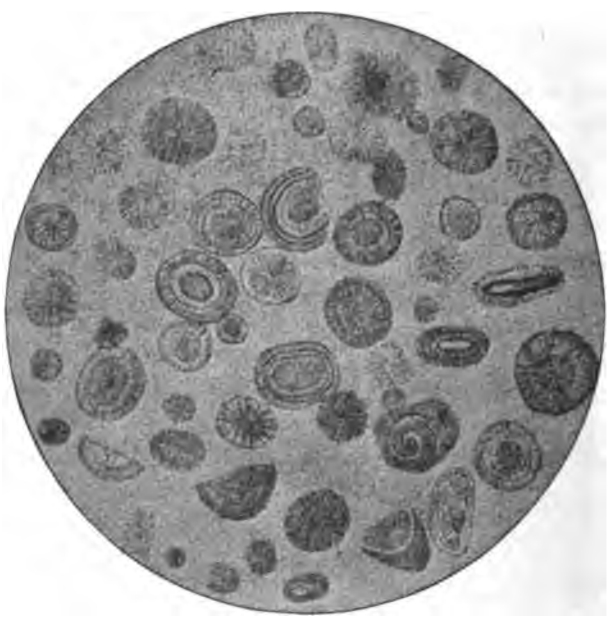

FIG. 3.

It will be seen that each concretion has a radiating structure, and most of them show concentric layers.

12. Pisolitic limestone (so-called from *pisum* a pea), has, so far as I know, only been found in Canada in rounded pieces in the conglomerates of the "Quebec Group." These contain many fossils, which are supposed to belong to the Upper Cambrian zone; the pebbles belong to the same geological horizon. I have found no radiating structure in any of these pisolite forms; but this peculiarity is seen in all sections of oolitic limestone. Sections of pisolite limestone from St. Anne, Bic, Point Levis, and other localities in the province of Quebec, show each concretion to be formed of concentric layers, in some cases little or no nucleus is found, while in others the nuclei forms three parts of the whole.

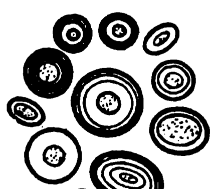

FIG. 4.

Fig. 4 shows several of the pisolitic forms cut through the centre. In the rock these little round balls are cemented together with so little calcareous matter that a slight tap with the hammer will detach them.

13. In 1892 a piece of oolitic limestone, collected from the Trenton rocks of Ottawa by W. R. Billings, was sent me for microscopic examination. Sections showed these minute concretions to be precisely like those of the limestones of Cape Breton and Arisaig. Fig. 3.

14. A limestone from the lower carboniferous of New Brunswick is partly made up of concretionary forms which, when weathered, might readily be taken for small stromatoporids, but which in thin slices under the microscope show a nucleus of crystallized calcite and concentric rings, between

which is a series of prismatic or vacerous lines See fig. 5, enlarged about ten diameters.

FIG. 5.

15. On the flat surface of the Potsdam sandstones, Upper Cambrian, of the coast of Labrador, fine examples of concretionary structure may be seen, some of them a yard or more in diameter, showing fine concentric lines of various shades of color which, when weathered, look like the lines of growth in a section of a tree, but no radial lines are seen. The sandstone is pierced by *Scolithus Canadensis*, (Billings). Fig. 6 is from a sketch of a detached piece lying on the shore.

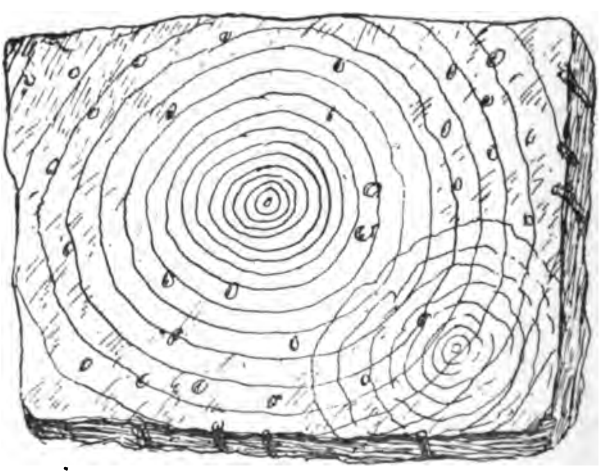

FIG. 6.

16. Besides the large trunk-like cylindrical concretions found in the Potsdam sandstones on the banks of the Rideau Canal, near Kingston, Ont., (Trans. Nova Scotian Inst. of Sci., Ser. 2, Vol. I.), there are many "stone potatoes," so-called by the quarrymen. These are spheroidal forms generally distorted, varying from the size of a rifle bullet to three inches in diameter, and composed of fine grains of translucent quartz. Many of them are stained with oxide of iron, while others are of a dirty white, the colour varying according to the tint of the rock in which they are enclosed. In some of these, concentric layers are faintly seen, but no radiating lines.

17. Hard calcareous concretions (nodules, as they are generally called), are among the most interesting objects of the Post-Tertiary (Leda Clay) deposits of Canada. The clay banks of Green's Creek, and the south shore of the Ottawa River, a little below Ottawa city, have been known for many years, and the fossils contained in the concretions of these localities recorded by many writers; but a few words here may not be out of place. The kidney form is the most common shape taken by these concretions, which generally enclose the skeleton of the well-known Green's Creek fossil fish, hundreds of which may be collected in a few days. It is a capelin, *Mallotus villosus* (Cuvier), in some cases so well preserved that every bone can be seen. Other forms are spheroidal, and contain for a nucleus a fragment of bone, a shell or grain of sand, or an insect. A large collection of these fossil bearing nodules or concretions was made by Dr. Ells of the Canadian Geological Survey during the summer of 1893, from Besserer's wharf, on the Ottawa River, near the mouth of Green's Creek. In one of these a fine leaf of *Populus balsamifera* was found.

In Sir J. W. Dawson's "Canadian Ice Age," a detailed account is given of our Post-Tertiary rocks, with illustrations of some of the principal fossils. Besides the common capelin before mentioned, we find the well-known mussel shell, *Mytilus edulis*, Linn., and two or three beetles, among which is *Byrrhus Ottawaensis*, the latter collected by Dr. Ami of the Geological Survey.

OTTAWA, March, 1894.

II.—The Iron Ores of Nictaux, N. S., and Notes on Steel Making in Nova Scotia. By E. Gilpin, Jr, LL.D., F. R. S. C., Inspector of Mines.

(Read 11th February, 1895).

It is commonly known that in the earlier days of the iron industry, pig iron was made by smelting iron ores in blast furnaces. The product was either melted again in foundries and run into moulds, or, as it is generally termed, used as cast iron. This every one is familiar with as the ordinary form of iron, of which a stove may be taken as a sample. Another application of the pig iron was for making wrought iron. This was effected by driving out the impurities of the pig iron by heating and oxidation, until it was practically pure and malleable. Horse shoe iron may be taken as an example of this variety. Still, another application of the pig iron was to turn it first into wrought iron, and then by restoring part of the carbon eliminated by the puddling process, to produce an iron intermediate between malleable iron and cast iron, and known as steel.

It was found at an early date that this latter product could be so manufactured as to fill as desired any grade between cast iron and malleable iron. It could be made to combine hardness, stiffness and tenacity, or on the other hand, to approximate in qualities to the very best malleable iron with certain additions of tenacity and strength. The discovery that it was possible to produce so useful a variety of iron, encouraged the best exertions of leading chemists and metallurgists. The problem was the cheap and regular production of steel in any grade required, soft or hard, for steel rails, or for those purposes requiring flexure and strength combined. With the certainty that fortunes awaited the happy discoverer of a commercially successful method of making steel, many experimenters labored for years, and under difficulties, which do not confront the metallurgists of the present day, succeeded partially in making

steel, but managed with more success in designing methods for producing malleable iron by direct processes which, however, could not compete in cheapness with malleable iron made from pig iron puddled by hand.

At this stage the Bessemer process appeared, and the difficulty was solved. Steel could be made with regularity of output and uniformity of composition, and it came at once into commercial competition with wrought iron. At first many difficulties were encountered, not the least of which was the disposition to doubt that a desired standard of uniformity in tensile and other tests could be maintained, Step by step the chemist and the steel maker advanced, this difficulty was solved by an enquiry into the composition of the ores, the fuels, the re-actions in the furnace, while the practical steel maker invented the improvements required in the shape of the convertors, the machinery needed to handle it, the linings, etc. Finally, the test requirements for steel rails, girders, etc., imposed by architects and engineers, were easily and regularly met, and it was acknowledged that steel was the king of all metals. Borrowing from other elements their properties, it became hard almost as a diamond, or flexible and soft so that it could be pressed without breaking into a dish or kettle. Few people taking up a piece of steel imagine what a long history of investigation, experiment, and down-right hard inventive work it represents, probably the greatest and most important of our generation

It was found to be a *sine qua non* that good steel required as its foundation good pig iron. Pig iron that did very well for common foundry purposes, or that could be puddled into fair bar iron, would not answer for the Bessemer process. This discovery called for the best of materials. Some ores were useless, some fuels carried too much sulphur or phosphorus, etc. The limits within which fuels and ores and fluxes were suitable for the Bessemer process were soon defined exactly, and of course the composition of the pig iron to be produced for conversion into steel was defined with equal exactness. The amounts of phosphorus, sulphur, silicon, etc., allowed in the pig iron were

inexorable, and iron fulfilling the conditions of purity became known as Bessemer pig. This always commands a higher price than ordinary pig iron, and at the present moment ranks next in price to pig iron made with charcoal, a very pure fuel, and the most expensive form of pig iron.

This necessity for a very pure variety of iron ore at first limited the production of Bessemer steel and kept up its price. Gradually, however, prospectors searched all parts of the earth within easy reach by water of England and Germany the early homes of this new process. It was soon found that Spain, Elba, and Algiers could be drawn upon for enormous supplies of ore of the requisite purity and cheapness. Rich ores were found on the north-west coast of England, and large steel works were started in Cumberland. Now iron ore is carried to England from Norway within the Arctic circle. Similar necessities led to the discovery of rich ores in Pennsylvania and on Lake Superior, and to the establishment of steel works at Chicago and other points in the United States.

The result of the ready supply of these cheap and pure ores, and the reduction of the Bessemer process to an exact science, was a steady course of declension in the malleable iron production, and in the production of pig iron, so far as its derivatives came into competition with steel. So noted is this in England that the output of iron ore in the Cleveland district has fallen from 6,000,000 tons to 4,000,000 tons a year. The ore of this district being of inferior quality, and capable of yielding only a pig iron, the conversion of which produced an iron incapable of competing with steel.

The effect of this cheapening of steel is most clearly shown in the case of steel rails which have replaced iron rails, and have themselves fallen in price per ton from $50 to $22.

The great advantage given by cheap water carriage and pure ores to the steel makers situated on tide water, produced a feeling almost of despair in the continental blast furnace districts, which were some distance from water carriage. They saw that their iron was being replaced by steel, and that the expense of

carriage acted as a measure of protection to their more fortunately situated competitors. It looked as if the steel production of the world was to be practically limited to those countries which had the opportunity of assembling at the water edge a good and cheap local fuel and a pure water borne ore; or, to a country like the United States of America, which, possessing both these requisites, had also a cheap land and water carriage, and an almost unlimited home market.

At this point in the history of steel an unexpected and important discovery was made. It was found that under certain conditions of manipulation, including a basic lining for the converters, *i. e.*, the use of substances such as magnesia, it was possible to convert phosphorus, the great enemy of the Bessemer process, into an important adjunct in steel making. As hitherto the limit for phosphorus in Bessemer ore (.07) was measured by hundreds of one per cent., and the great difficulty was to find iron ores free from it in large enough quantities to ensure a regular and cheap supply, it is plain that when as much as three per cent. of phosphorus was permissible in the new process, a fresh field was opened up. Briefly speaking, the process consisted in the burning out of the carbon, silicon, and sulphur, by manganese and the phosphorus, the latter after discharging its kind offices practically eliminating itself.

As was to be expected, this process, known as the Thomas Gilchrist, specially recommended itself to the German steel makers who had at hand large supplies of low grade ores. Large establishments were started there and at other points on the continent, and now the Bessemer steel makers of England find their markets successfully invaded by the makers of basic steel. In spite of the experience thus gained during the past few years in England, the steel makers there, bound by prejudice, are only now awaking to the fact that they must be distanced by the continental steel makers, unless they adopt the process based on the poorer and cheaper ores. Thus the inventive faculties of two men threaten to divert a great trade, and to starve an industry in which millions are invested in England.

The extent to which the manufacture of basic steel has been carried in Germany may be gathered from the fact that in 1894 the production of pig iron there was in round numbers 5,000,000 tons, of which nearly 50 per cent. was Thomas iron. In England in 1894 the percentage was about 15. In the United States matters are much as in England, indeed the percentage of basic pig is less. Here, however, the conditions are different. The cheap supplies of pure ore available at Chicago, Cleveland, etc, from the iron mines of the Lake Superior district, and a protective tariff, have permitted an adherence to the firmly established Bessemer process But the fact remains that in the markets open to the competition of the world the cheap steel, low wages, and reasonable freights of the German steamers, combine to enable them to undersell American and English competitors.

No metallurgical process during the past thirty years has received more attention from the chemist and capitalist than the relation of phosphorus to iron and steel. Interminable researches on the part of chemists and analysts, costly experiments, in which capital has lavishly poured out its money, have combined to force from nature the secret of pure steel. As we have seen, the iron ores of the world are divided, as regards steel, into Bessemer and non-Bessemer, according to the proportions of phosphorus present.

Speaking in round numbers of the 12,000,000 tons of steel made in 1893, about 75 per cent. are made of ores that contain not more than .07 of phosphorus to the 100 parts of iron. The remaining 25 per cent. are made from ores containing from .10 to 2.50 per cent. of phosphorus.

The principle governing both processes of steel making are based on the fact, practically correct, that all the phosphorus in the ore smelted in the blast furnace goes into the pig iron. It thus happens that in the case of a Bessemer pig iron the phosphorus is a trace, while in the case of a basic pig iron it may run as high as 2.5 per cent.

Bearing these distinctions in mind, the question of the adaptability of the iron ores of any district in the Province of Nova

Scotia to steel making, by either of the above processes, may be intelligently considered.

In the Province of Nova Scotia we have entered upon the steel making era. In one sense this was the case twenty-five years ago, when cement steel was made at Londonderry from the product of a small charcoal furnace. From a practical standpoint, however, steel making may be said to have commenced when the New Glasgow Iron, Coal and Railway Company made Bessemer pig at Ferrona, in Pictou County, for conversion into steel at Trenton. The ores belonging to this company, on the East River of Pictou, produce a pig admirably suited for the Bessemer process. For more common grades the company has drawn upon Torbrook, and are preparing to import from Newfoundlaud ores which exert a softening effect on the pig iron and fit it for foundry use. Favorably situated as this company is for very pure ores, cheap and close at hand, the basic process presents few attractions. It may be predicted that when the other iron ore properties of the Pictou district become developed it will be a great steel producer, and also be in a position to supply the demand of the foundryman.

In the Nictaux district, in Annapolis County, on the contrary the conditions, so far as they are worked out, resemble rather those of Germany, and a vast series of ores are presented suitable for the basic process, in addition to some which can be graded as Bessemer.

Nictaux is the name given to a district on the south side of the Annapolis Valley, about thirty miles from Annapolis. It is traversed by the Nova Scotia Central Railway from Middleton on the Windsor Railway to Lunenburg on the Atlantic; and by the Nictaux River, which has cut deeply into the south mountain. The geological age of this iron-bearing district has been partially worked out by Sir William Dawson, who refers the iron ore rocks to the Devonian. I shall however not enlarge on this point, as Dr. A. H. MacKay has spent some time in the district, and has kindly consented to describe the geological features in detail.

The district extends from a point several miles west of the Nictaux River to the county line between Annapolis and Kings, and probably some distance further. It varies in width up to about five miles. In this section there are a number of beds of iron ore having a general north-east and south-west course. While exposures are frequent, there are undulations and fractures in the measures which render any positive correlation of the ore beds a matter of uncertainty, owing to the limited exploratory work yet effected.

The most northerly range of iron-bearing strata is represented by the bed worked at the Torbrook mine. This has been traced about 2 miles eastwardly to the county line, and for some distance to the westward. Exposures of red hematite, near Nictaux Falls, are believed to show its further passage in that direction.

South of this comes the deposit known as the "Shell Ore" bed, which was worked for several years by long trenches running on its outcrop. Its principal exposure is on the Banks farms, where it is from five to eight feet thick. This ore is highly fossiliferous, and has furnished many interesting fossils to visiting geologists

Still further south on the Canaan Mountain road, about 2 miles south-west of the Torbrook mine, are two beds of red hematite 4 to 6 feet thick. These beds, assuming a westerly course, apparently coincide with an exposure of red hematite ore reported on the southern end of the Banks farm. The further westward extension of these beds is unknown, they may in a magnetised condition be represented in the Page and Stearns beds on the west side of the Nictaux River. Here mining operations have exposed eleven beds from 2 to 10 feet in width. These beds, with others lying on the same horizon a little to the south, one of which on the river bank is about 12 feet wide, extend to the westward nearly 2 miles to the Willett property in the rear lines, where two beds, each about 5 feet thick, have been uncovered.

South of this range, on the Torbrook, other beds of magnetite and shell ore are exposed on the Armstrong and other farms,

some of which reach a thickness of 20 feet. Some of these beds are stated to have been traced for a distance of six miles. Still further to the south, beyond the township line, specular ore is said to occur in a vein 6 feet wide.

While the work done in this district has shown the presence of numerous beds of iron ore, much is still needed to trace their relative positions, their continuity and their economic value. The continuous extension of all the beds in an unbroken line from end to end of the district can hardly be hoped for, as there are evident dislocations at several points, and flexures of the strata. As to the quantity of ore there can be no question. The amounts available above the water levels of the Torbrook and Nictaux Rivers must be enormous.

The question of the economic values of the ores must be the subject of extended investigation. Practical working has shown that the red hematites can furnish a foundry and forge pig The magnetites are with some exceptions too phosphoric for this purpose. The percentages of this element vary between °5 and 2.00 in the different beds. The ores are as a rule silicious, and in some cases manganiferous, but low in sulphur. They are not to be compared in purity with the magnetites of the North Mountain on the opposite side of the Annapolis Valley. Here the ores are as a rule of unusual purity, but they have not as yet been found to occur in amounts of economic value. They are presented as veins in the trappean rocks, highly crystallised and often showing banded structure, with layers or crystals of amethyst, quartz, etc.

The ores of the district run high enough in iron and phosphorus and low enough in sulphur to answer for the basic process, and their large silica contents would prove the principal obstacle to their use for this process. I believe, however, that on the continent furnace managers have been able to successfully meet this trouble when smelting for the basic process. No doubt further search will show ores running lower in silicious matter, and the large deposits of bog ore in this district can be also utilized in this connection.

To upset these drawbacks it must be remembered that the mining of these ores and their transportation would be cheaper than from almost any other iron ore district in Nova Scotia, and the preliminary outlays for machinery, drills, wire, tramways, etc., be reduced to a minimum by the facilities available for utilizing water power for generating electrical power.

The following tables of analysis of samples from the outcrops of a number of these beds, as well as from the underground workings of the Torbrook mine, will serve to give an idea of the values of these ores :—

The following analyses show the quality of the ore mined at Torbrook :

Metallic Iron....52·44, 60·72, 59·00, 61·38, 47·00, 55·74, 74·59, 11·57, 57·93, 59·86.
Silica ....11·00, 10·28, 12·86, 26·50, 10·12, 14·97, 17·21, 5·93, trace.
Phosphorus...... 1·66, .17, trace, 1·08, trace, ·18, ·17, ·16, none.
Sulphur........None, trace, trace, trace, trace, ·23, ·08, ·09, 0·36, ·11,
Lime............ 2·70, trace, 2·16.
Magnesia .... ·41, trace, trace.
Alumina .... 5·53, trace, 3·14.

Analyses of crop sample from beds on Armstrong's and other farms :

	Iron.	Silica.	Phosphorus.	Sulphur.	Manganese.	Titanic Acid.
1.—	54·71	11·56	·669	·007	....	....
2.—	42·80	10·39	·396	·015	·52	....
3.—	54·84	10·87	1·452	·015	·41	·144
4.—	53·10	14·16	·704	·025	·24	....
5.—	55·40	20·35	1·037	·114	·26	....
6.—	54·28	7·97	·53	·028	·28	....
7.—	52·40	9.41	1·861	·030	·23	....

Miscellaneous analyses of ores in the Cleveland and Torbrook districts:

Magnetites.

	No. 1.	No. 2.	No. 3.	No. 4.
Metallic Iron......	54·22	59·11	53·14	54·96
Silica	14·97	11·64	....	11·12
Sulphur	·069	·09	....	trace.
Phosphorus	·36	·17	·172	·192
Alumina	5·53	....	....	3·14
Lime	2·70	....	....	5·88
Magnesia	·41	....	....	2·01
Manganese	·86	....	....	....

Red Hematite.

Metallic Iron	58·05	57·93	18·47
Silica......................	....	17·21	33·50
Sulphur	....	·03	....
Phosphorus	·193	·16	....
Alumina	....	....	....
Lime	....	....	3·00
Magnesia	....	....	....
Manganese	....	....	9·80

Mining development of the Nictaux distrtct.

The existence of iron ore was known here at an early date in the history of Annapolis County. Haliburton, writing in 1829, speaks of the first attempt as "an ill directed effort made many years ago." I am unable to give any particulars of this operation, but presume it was directed to the manufacture of wrought iron by a forge process. The hard compact ores of the district were not suited to this primitive method.

Gesner gives an interesting account of the iron ore deposits of Annapolis County, and refers to the bed of shell ore on the Banks farm as 6 feet 6 inches wide. In 1856 another attempt was made and a furnace built at the falls. The iron produced was largely from the shell bed, and is stated to have been of inferior quality. Harrington gives some details of these furnaces

in his report on Canadian Iron Ores, 1874. The fuel used was charcoal, readily furnished by the great forests to the south. Some years later the ores of the district again received attention during the construction of the Nictaux and Atlantic Railway. The Messrs. Page and Stearns opened a number of beds on the west bank of the Nictaux River. A few experimental cargoes were shipped, and some was found to be of very good quality. Delays in the building of the railway led to the closing of the mines. These beds were magnetite, massive and fine grained.

A few years ago Mr. R. G. Leckie secured the outcrop of a bed of excellent red hematite at Torbrook, about three miles east of Nictaux, which has been worked since by the Torbrook Iron Co. The bed runs about north-east and south-west, with a steep dip to the north, and is enclosed in soft slates. The ore is massive and fine grained, and as shown by analysis, an excellent foundry material, The mine is well equipped and opened for a length of about 1,500 feet, and to a depth of about 200 feet, the bed being from five to seven feet thick. Up to date about 80,000 tons have been mined here, which has been used by the Ferrona and Londonderry furnaces as a mixture with their harder ores.

Captain Hall, of Middleton, has for several years paid much attention to the ore beds, and owns a number of properties covering large and valuable deposits.

III.—True Surfaces and Accurate Measurements. By D. W. Robb, A. S. M. E., *Amherst, N. S.*

(Received 24th November, 1895).

That absolute truth is almost unattainable, becomes apparent to the skillful mechanic as well as to the thoughtful scientist, and the degree of success of each may be measured by the nearness of approach to absolute accuracy, whether it be in the result of the scientist's reasoning, or the more material product of the mechanic's hands.

For the production of flat surfaces of metal, the mechanic uses an instrument called the "surface plate," which is simply a plate of cast iron well stiffened by ribs and resting upon three points of support to prevent springing, the upper side of which is carefully scraped by hand until its surface is approximately true. When one of a pair of such "surface plates" is placed with its trued surface above the other it will not immediately come in contact with the lower plate, but will for a time float upon the air confined between the surfaces, because the air can only escape at the edges, and, as the plates come closer together, it will do so more slowly so that a noticeable time, depending upon the truth of the surfaces, weight and size of plates, will elapse before the plates will really touch each other. When the air is fully excluded, or as fully as the truth of the surfaces will allow, the plates will adhere, or rather the atmospheric pressure on the outside will press them together.

It is evident that, if we interpose between the surface plates a fluid, more viscid than air, such as oil, it will require a longer time and greater weight to expel it, and we may move the upper plate back and forth for a long time before the plates come into direct contact, the particles of fluid forming a perfect system of rollers, upon which the metal will roll with very slight friction. If we provide means whereby the oil will be renewed, the iron will never come into contact, provided the

pressure of the upper plate is not sufficient to overcome the capillary attraction, and force the oil out. It will at once be recognized that this is the principle upon which all lubricated bearings or journals of machinery, whether flat or round, are constructed. This somewhat minute and elementary explanation is given in order to show the importance of truth in the surfaces of the bearings of machinery, to have flat bearings truly flat and round bearings truly round. If such surfaces are uneven, as they will be when made by the ordinary method of turning or planing, owing to the springing of the cutting tools and uneven texture of the metal, lumps will be produced which will project through the oil, and the metals will touch each other producing, when moving past each other at a high rate of speed, friction and wear so common in machinery. But it has been proved by experiment that, if the surfaces be made nearly true, so that the lubricant will completely separate the metals, and the bearing sufficient in area to withstand the weight imposed without forcing the oil out, such journals may be run without wear, and that the rate of speed, within practicable limits, makes no difference. The question will at once suggest itself: Why not make all the bearings of machinery perfectly true, sufficiently large in surface, provide continuous lubrication, and prevent wear entirely? I may say that a very great advance has been made in this direction. In the higher grades of machinery, manufacturers use delicate grinding and scraping processes to produce smooth and true surfaces, with the result that many machines, such as electric dynamos and steam engines, which run at a high rate of speed, have practically no wear in their journals, but it is just here the mechanic learns how hard it is to obtain absolute perfection. He may be able to produce a sufficiently true surface, but he finds he cannot overcome the distortion of metals, due to unequal pressure, or heat. As he approaches greater refinement in producing true surfaces, he will learn that it is impossible to get them to remain true when subjected to the strains incident to the conditions under which they work. He finds that, if he lifts his surface plate by one corner it is less true, if I may be allowed the expression, than

when resting upon its three supports, or that his straight edge, which was about straight when resting upon the surface plate, bends slightly when he lifts it by the ends. A machine designed and constructed with the greatest care and skill, when subjected to the necessary strain of belts, or the inertia of its own rapidly moving parts, will spring so that the bearings, which have been made nearly perfect in surface and alignment, are thrown slightly awry, causing the strain to be borne by a decreased area, and forcing the lubricant out. The skill of machine designers is shown in designing a machine so that the journal and its seat will spring together, thus preserving the adjustment of bearing surfaces. We hear and see much in these days of ball bearings. The success of the modern bicycle depends upon this ingenious device, and has induced almost a mania for using hardened steel balls for bearings of all kinds. Those engaged in mechanical work often forget that the old and tried oil lubrication is really a ball bearing composed of such perfectly formed balls as only nature can produce, and with the advantage that they may be replaced or renewed as often as desired with very slight trouble. Steel balls are undoubtedly better suited to a bicycle than ordinary bearings lubricated by oil, because it is impossible to get a machine light enough for the purpose and have the bearing surfaces large and parts sufficiently rigid to keep the surfaces in correct alignment; but in heavy machinery where the strain on bearings is so much greater, steel balls, with their small surface of contact and tendency to crush, are not as suitable as the minute spheres of a fluid such as oil. In this connection may be mentioned a point which is also closely connected with the second part of this subject, accurate measurements, viz., that it is necessary in the construction of bearings of machinery to allow sufficient space for the oil between the metals. If a shaft be made as perfectly round and smooth as possible, and of the exact size of the bushing or box in which it is to work, which is also true, there will be no room for the lubricant. The writer has seen this fact well illustrated by a bar which was intended to carry revolving cutters in a machine for boring cylinders, both the bar and the bush were made as carefully as possible

and to fit closely. The bar fitted the bush so well that while it could be shoved into its place when free and clean from oil, when oil was applied it refused to move except by using considerable force, showing that there was not room for the oil. The shaft required to be reduced 2/1000″ in size to make room for the lubricant. Heating of journals is frequently caused by neglect of this point. In many kinds of machinery no attempt is made to true the surfaces carefully, or indeed to do more than get them approximately round or flat, as the case may be, or to make them to any exact size nearer than can be measured by the eye or an ordinary box wood rule. The result is that journals and seats have to work out their own salvation or destruction, by wearing the high parts down until the low parts approach near enough for the oil to support the whole journal, consequently, much care and patience must be exercised in working new machinery until it is worn to a bearing, otherwise the metals will abrade and heat by friction until the surfaces are completely destroyed.

The foregoing will emphasize the importance of being able to make minute and accurate measurements, as much depends upon the certainty with which the mechanic can measure the inaccuracies of his work in order to bring it to the necessary state of perfection. The ordinary system of measuring by a rule graduated to 16ths, 32nds or perhaps the 64ths of an inch, the use of which leaves room for an error which is too great for the production of good machinery, has been superseded in machine shops, where accuracy is aimed at, by the "Micrometer Caliper" and hardened steel gauges of various kinds, by means of which measurements of 1/4000 of an inch can be made as easily as 1/16 inch can be measured by the ordinary rule.

"The Interchangeable System," first used by American workmen in the production of watches, fire arms, and other machines, having a number of small parts, any one of which should fit any other, has done much to introduce refined and rapid methods of measurements. Steel gauges, which are hardened and then ground, are now produced by manufacturers of tools which are

guaranteed to be accurate within 1/10000 of an inch, and when such gauges are applied to a piece of machinery there is no difficulty in producing work rapidly and uniformly correct within 1/4000 or 1/5000 of an inch.

In addition to the evident advantage this system has over the old "Cut and Try System," by which each part of a machine was fitted especially to the other part, it eliminates the individual factor to a considerable extent, so that perfection of product is not so much dependent upon the individual whose skill has been acquired by long years of experience, and who must have produced much inferior work before he attained his present deftness. The manufacturer is enabled to furnish plans of each machine giving the exact sizes, marked in thousandths of an inch, and each mechanic is able, by the aid of his gauges, to produce any number of parts which are exactly alike, and will fit any other part of similar machines. By preserving this uuiformity in all the machines he produces, the manufacturer is able to determine accurately from the machines in use where imperfections exist, and can record and store up his accumulated experience and make corrections and improvements as required.

IV.—RELICS OF THE STONE AGE IN NOVA SCOTIA. BY HARRY PIERS.

(Read 13th May, 1895.)

Not long ago I had the honour of reading before the Institute of Science a paper describing a number of aboriginal relics found in this province. It was based on a study of the many excellent specimens preserved in the cases of the Provincial Museum, Halifax. Since that time, a quantity of undescribed and very interesting material has been placed in my hands, which I shall herein describe.

A number of years ago the late Charles W. Fairbanks, Esq., C. E., formed a collection of stone implements which had been discovered in Nova Scotia. Most of these relics were given to him by William M. King who found them while clearing and plowing the land on his farm at the head of Grand Lake, Halifax County. The place was doubtless a prehistoric camping ground, but I do not know whether the Micmacs continued to resort there within the memory of man.

Mr. Fairbanks's collection is now the property of his son, Charles R. Fairbanks, Esq., of Halifax, to whom I am indebted for permission to examine and describe the specimens. Very unfortunately none of them bear labels, and therefore the exact localities where they were found are unknown; but there is no doubt that they are Nova Scotian, and probably nearly all were found on Mr. King's farm.

I have also to thank several other gentlemen whose names are subsequently mentioned, for permission to study implements in their possession.

These specimens, together with some in the McCulloch collection of Dalhousie College Museum, and others of my own, constitute the material upon which the present paper is founded.*

* Judge DesBrisay of Bridgewater, N. S., most courteously offered me the privilege of examining and describing his excellent collection of aboriginal remains; but I have so far been unable to take advantage of his kindness.

LESCARBOT'S ACCOUNT OF THE MICMACS.

Before entering upon a description of these implements, it may be well to consider the habits of our Indians as described in the writings of one of the early voyagers. This will help us much to understand the subject with which we deal. The first exact and extensive account of the Micmacs, and by far the most interesting, is to be obtained from the description of New France written by the old French advocate, Mark Lescarbot, who in 1606 accompanied Poutrincourt to Acadie. He dwelt for some time at Port Royal, now known as Annapolis, which had been founded in the previous year by Pierre du Guast, Comte de Monts. From an English version* of Lescarbot's rare book, in the library of the late Dr. Akins, I have made some transcripts which follow in the quaint language and spelling of the translator. These extracts will be of great interest to any who are studying the archæology of Nova Scotia, for Lescarbot wrote at the period when iron implements were only beginning to supplant those of stone. Dr. J. B. Gilpin has already given us much information gathered from this writer, but seldom in the latter's language.

Speaking of the dress of the Indians, Lescarbot says they wore "a skin tied to a latch or girdle of leather, which passing between their buttocks joineth the other end of the said latch behind; and for the rest of their garments, they have a cloak on their backs made of many skins, whether they be of otters or of beavers, and one only skin, whether it be of ellan, or stag's skin, bear, or lucerne, which cloak is tied upward with a leather ribband, and they thrust commonly one arm out; but being in their cabins they put it off, unless it be cold....As for the women, they differ only in one thing, that is, they have a girdle over the skin they have on; and do resemble (without compari-

* "Nova Francia: or, the Description Of that Part of New France, Which is one Continent with Virginia....[by Mark Lescarbot, advocate]. Translated out of the French into English, by P. E[rondelle]." The Akins copy is bound separately, but it originally formed pp. 795-917 of the second volume of Osborne's *Collection of Voyages and Travels, compiled from the Curious and Valuable Library of the Earl of Oxford*, London, 1745-47, 2 ls., folio, generally called the Harleian Collection of Voyages.

son) the pictures that be made of St. John Baptist. But in winter, they make good beaver sleeves, tied behind, which keep them very warm....Our savages in the winter, going to sea, or a hunting, do use great and high stockings, like to our boot-hosen; which they tie to their girdles, and at the sides outward, there is a great number of points without taggs ...Besides these long stockings, our savages do use shoes, which they call *mekezin*, which they fashion very properly, but they cannot dure long, especially when they go into watry places, because they be not curried nor hardened, but only made after the manner of buff, which is the hide of an ellan....As for the head attire, none of the savages have any, unless it be that some of the hither lands truck their skins with Frenchmen for hats and caps; but rather both men and women wear their hairs flittering over their shoulders, neither bound nor tied, except that the men do truss them upon the crown of the head, some four fingers length, with a leather lace, which they let hang down behind." [Book II, chap. ix.]

Describing the complexion of the savages, Lescarbot says: "They are all of an olive colour, or rather tawny colour, like to the Spaniards, not that they be so born, but being the most part of the time naked, they grease their bodies, and do anoint them sometimes with oil, for to defend them from the flies, which are very troublesome.....All they which I have seen have black hairs, some excepted which have Abraham colour hairs; but of flaxen colour I have seen none, and less of red." [Book II, chap. x.]

The Indians "have *matachias*, hanging at their ears, and about their necks, bodies, arms, and legs. The Brasilians, Floridians, and Armouchiquois, do make carkenets and bracelets (called *bou-re* in Brasil, and by ours *matachias*) of the shells of those great sea cockles, which be called *vignols*, like unto snails, which they break and gather up in a thousand pieces, then do smooth them upon a hot stone, until they do make them very small, and having pierced them, they make them beads with them, like unto that which we call *porcelain*. Among those

beads they intermingle between spaces other beads, as black as those which I have spoken of to be white, made with jet, or certain hard and black wood which is like unto it, which they smooth and make small as they list, and this hath a very good grace.... They esteem them more than pearls, gold or silver....But in Port Royal, and in the confines thereof, and towards Newfoundland, and at Tadoussac, where they have neither pearls nor vignols, the maids and women do make *matachias*, with the quills or bristles of the porcupine, which they dye with black, white, and red colours, as lively as possibly may be, for our scarlets have no better lustre than their red dye; but they more esteem the *matachias* which come unto them from the Armouchiquois country, and they buy them very dear; and that because they can get no great quanity of them, by reason of the wars that those nations have continually one against another. There are brought unto them from France *matachias* made with small quills of glass mingled with tin or lead, which are trucked with them, and measured by the fathom, for want of an ell." [Book II, chap. xii.]

"Our savages have no base exercise, all their sport being either the wars or hunting . . . or in making implements fit for the same, as Cæsar witnesseth of the ancient Germans, or in dancing . . . or in passing the time in play." Lescarbot then describes their bows and arrows, but as I have elsewhere referred to this account, it may be here omitted. "They also," he says, "made wooden mases, or clubs, in the fashion of an abbot's staff, for the war, and shields which cover all their bodies.....As for the quivers that is the women's trade. For fishing: the Armouchiquois which have hemp do make fishing lines with it, but ours that have not any manuring of the ground, do truck for them with Frenchmen, as also for fishing-hooks to bait for fish; only they make with guts bow-strings, and rackets, which they tieat their feet to go upon the snow a hunting.

"And for as much as the necessity of life doth constrain them to change place often, whether it be for fishing (for every

place hath its particular fish, which come thither in certain season) they have need of horses in their remove for to carry their stuff. Those horses be canoes and small boats made of barks of trees, which go as swiftly as may be without sails: when they remove they put all that they have into them, wives, children, dogs, kettles, hatches, *matachias*, bows, arrows, quivers, skins, and the coverings of their houses. . . . They also make some of willows very properly, which they cover with the . . . gum of firr-trees; a thing which witnesseth that they lack no wit, where necessity presseth them." [Book II, chap. xvii.]

Lescarbot says that anciently the Souriquois or Micmacs made earthen pots and also did till the ground; "but since that Frenchmen do bring unto them kettles, beans, pease, bisket and other food, they are become slothful, and make no more account of those exercises." [Book II, chap. xvii.]

Elsewhere in the volume the writer also tells us that the labour of grinding corn to make bread "is so great, that the savages (although they be very poor) cannot bear it; and had rather to be without bread, than to take so much pains, as it hath been tried, offering them half of the grinding they should do, but they chused rather to have no corn." [Book I, chap. viii.]

Writing of the women, he says, that "when the barks of trees must be taken off in the spring-time, or in summer, therewith to cover their houses, it is they which do that work; as likewise they labour in the making of canoes and small boats, when they are to be made; and as for the tilling of the ground (in the countries where they use it) they take therein more pains than the men, who do play the gentlemen, and have no care but in hunting, or of wars. And notwithstanding all their labours, yet commonly they love their husbands more than the women of these our parts." [Book II, chap. xviii.]

Once Lescarbot saw meat cooked by an Indian in the following manner. The savage "did frame with his hatchet, a tubb or trough of the body of a tree," in which he boiled the flesh by putting "stones made red hot in the fire in the said trough," and replacing them by others until the meat was cooked. [Book II, chap. xxi.]

Speaking of some Indians who followed the French vessel along the sands, "with their bows in hand, and their quivers upon their backs, always singing and dancing, not taking care with what they should live by the way," the worthy advocate exclaims with enthusiasm, "Happy people! yea, a thousand times more happy than they which in these parts made themselves to be worshipped; if they had the knowledge of God and of their salvation." [Book I, chap. xiv.]

We shall now leave the old French narrator and proceed to discuss the examples of aboriginal skill with which this paper is chiefly concerned. In classifying the specimens, I have principally adopted the arrangement given by Dr. Charles Rau in his account of the archæological collection of the United States National Museum (Washington, 1876.) In a few cases, however, I have found it necessary to depart slightly from his nomenclature.

A.—FLAKED AND CHIPPED STONE.

Arrow-heads.—The collection before me contains eleven specimens which I have so denominated (Plate I, Figs. 1 to 11). This is rather a small number, but it is very likely that several have been lost or given away since the formation of the collection. Some of the implements are flaked with great skill. With one exception, to be hereafter noted, all are formed of silicious stones, mostly jaspideous, such as are found in the western parts of the province. None have been polished in any degree. All are the result of the ordinary process of flaking by pressure. The points are mostly unfractured. In length the specimens vary from 1·25 in. (Fig. 8) to nearly 2·75 ins. (Fig. 4). Larger implements of this kind are denominated "spear-heads." The distinction, however, is an arbitrary one; for without the handle, which almost invariably has utterly decayed, there is no means by which an archæologist, in the present state of our knowledge, can form a fixed rule by which he may assert positively whether a given head was used as a spear, an arrow, or a knife. It is very likely that some of the larger so-called arrow-heads, as well as many of the "spear-heads," were hafted and employed as

cutting tools. Owing to this uncertainty as to the method of use, Dr. Wilson of the U. S. National Museum, in his Study of Prehistoric Archæology (1890), treats of all these implements under the general head of "arrow- or spear-heads, or knives."

Two specimens (Figs. 1—2) are leaf-shaped with rounded (convex) bases. The proportions and finish of one of these (Fig. 2) makes it possible that it may have been a leaf-shaped implement either intended to be hafted as a knife, or else inserted in the head of a club. In appearance it resembles some of the palæolithic implements of Europe, and it probably belongs to that hitherto much neglected class of aboriginal remains which Dr. Wilson considers to be indicative of a palæolithic period in American archæology. Professor Wilson's researches in this direction are most interesting and important, and open a new and wide field for investigation.*

Another specimen (length 1·8 in.) is straight-sided with a slightly concave base (Fig. 3). Five well-formed specimens (Figs. 4-8) are notched at the sides near the base. This class includes both the largest and the smallest example (2·75—1·2 ins.). The former (Fig. 4) would have been grouped with the spear-heads but for its slight proportions. A sixth specimen (Fig. 9) is broken, but possibly belongs to this class. Only one (Fig. 10) is stemmed and has a slightly concave base. The stem, like the notched sides before mentioned, was to facilitate the attachment of the head to a shaft. The last specimen to be considered, is barbed and stemmed (Fig. 11). It is 1·50 inch in length, and is neatly chipped from an olive-green or slightly smoky-coloured material, which from the smooth, curved surface of one side, and other appearances, seems to be nothing but bottle-glass.

An interesting account of the bows and arrows of our Indians is found in the quaint account of the old French advocate before quoted. The bows, saith Lescarbot, "be strong and without fineness." "As for arrows," continueth he, "it is an admirable

* *Vide* Thomas Wilson's "Results of an Inquiry as to the existence of Man in North America during the Paleolithic Period of the Stone Age." (*Report of U. S. Nat. Museum*, 1887-88).

thing how they can make them so long and so strait [*sic*] with a knife, yea with a stone only, where they have no knives. They feather them with the feathers of an eagle's tail, because they are firm and carry themselves well in the air: and when they want them they will give a beaver's skin, yea, twain for one of those tails. For the head, the savages that have traffic with Frenchmen do head them with iron heads which are brought to them; but the Armouchiquois,* and others more remote, have nothing but bones made like serpents' tongues, or with [*sic*] the tail of a certain fish called *sicnau*. . . . As for the quivers, that is the women's trade." Bow-strings, according to the same authority, were made of intestines, and snow-shoes or rackets were strung with the same material.

Spear-heads (or Cutting Implements?).—Two stemmed specimens (Figs. 12-13), one perfect, the other without the point, are in the Fairbanks collection. The uninjured one is three inches long, and the other, without doubt, was the same length. Two fragments (Figs. 14-15), one of which (Fig. 14) had been a very beautiful and delicate weapon, may also be placed in the present class. A fifth specimen (Fig. 16), 3·50 inches long and somewhat thick, formed of an argillaceous stone, roughly flaked, may be a spear-head or else a leaf-shaped implement for use as a cutting tool or for insertion in the head of a club.

The McCulloch collection, Dalhousie College, Halifax, contains a few stone implements, among which is a stemmed and slightly barbed spear-head (Fig. 82), 4 inches in length and 2·25 inches in greatest breadth. The same collection also contains a leaf-shaped implemement (Fig. 81) of white quartz, 4·75 inches long and 2 inches in greatest breadth.

There remain to be described a couple of implements which may best be considered here, although, strictly speaking, they are of polished stone. The inconsistency of placing them under the general head of flaked implements, is immaterial and may be pardoned.

* The Indians who lived in what is now New Hampshire and Massachusetts.

Mr. Henry Sorette, of Bridgewater, N. S., has sent me a drawing of a very remarkable implement of unusual length which was found with other relics while excavations were being made for a canal at Milton, Queen's County, N. S. The implement may be likened to a poniard blade. Apparently it had been ground into shape. It is 18 inches long and tapers regularly from 1·75 inch in width at the base, to about ·75 of an inch (according to the drawing) in width at a distance of about three-quarters of an inch from the end, where it suddenly diminishes to a point. Mr. Sorette's drawing seems to indicate a central line of elevation from base to point. My informer thinks it is made of hard slate. While being taken from the ground, it was broken into four pieces. Doubtless this relic was a ceremonial implement, such as some of the exquisitely flaked blades, long and delicate, which have been found in California.* Its fragile character would forbid any rough usage such as that of war or sport. Strange to say, one or more other implements of this type were discovered with it at Milton. Mr. John S. Hughes of the Milton Pulp Company, in a letter to me relative to this discovery, says, "quite a number of relics were found when we were excavating for the canal; they consisted of stone chisels, gouges, and 'swords or fish-spears' about 20 to 24 inches long [i. e., poniard-shaped stone blades, one of which has just been described]. The articles were generally kept by the finders. Out of the lot I got one gouge, and Mr. Sorette has one of the swords."

In the McCulloch collection already referred to, there is a polished slate "spear-head" with a stem notched on the sides to facilitate the attachment of a handle or shaft (Fig. 83). A portion of the point, probably about three-quarters of an inch, is missing. It measures nearly 6·50 inches in length, by 1·35 inch in width at the base of the blade, from which place it tapers very gradually to the broken point. The central portion of the blade is flat. This flat part is bordered on both sides by con-

* See *Report of U. S. Geographical Surveys west of 100th Meridian*, vol. vii, (Archæology), page 49 *et seq.*

spicious bevels, thus forming the edges. The specimen is unlabelled, but all of the implements in the collection of which it forms part are understood to have been found in Nova Scotia. Ground stone implements of this kind are extremely rare in the province. Dr. J. B. Gilpin in his account of the stone age of Nova Scotia (*Transactions N. S. I. N. S.*, vol. iii.) mentions an arrow-head which was polished like a celt and made of hardened slate ; and a spear-head also of slate, similarly fashioned, is referred to in my account of the aboriginal remains in the Provincial Museum. These are all which have come to my notice.

Before passing to the next class, I may repeat that I consider it extremely unlikely that the implements now under notice were actually used as spear-points. Arrow-shaped implements more than 2·75 inches in length, have been denominated spear-heads in this paper more from the general custom of archæologists than my own inclinations. Lescarbot makes no mention of spears as one of the weapons of the Micmacs or Souriquois of his day, although he enumerates with a good deal of detail their other implements of war, such as bows and arrows, and clubs.* This negative evidence has not been sufficiently noted. It is far more probable that most of the so-called spear-heads and leaf-shaped implements found in Nova Scotia, are knives. Our Micmacs had stone tools for fashioning bows and arrow-shafts and for skinning animals, and yet they are seldom recognized by collectors. This indicates that the Indian knife has been confounded with some other implement which it resembles. "Collectors are very ready," says Dr. Rau, "to class chipped stone articles of certain forms occurring throughout the United States as arrow- and lance-heads." Such has been much the habit of our local writers. The spear-shaped implements must be considered as being fairly adapted for cutting. The Pai-Utes of Southern Utah, up to the present time employ as knives, blades

* Rev. John Mecklenburg, or as he classically wrote his name, Johannes Megapolensis, in his *Short Account of the Maquas Indians in New Netherland*, written in 1644, also makes no mention of spears as weapons of war among the Indians of that locality. He speaks of bows and arrows, stone axes and mallets.

made of chipped stone and identical in form with what are too frequently termed spear or arrow-heads. These are inserted into short wooden handles. According to Major J. W. Powell, these knives are very effective, especially in cutting leather. The natives of Alaska still occasionally use knives formed in a similar manner, which they carry in a rough wooden scabbard. A most significant fact is mentioned by the late Dr. Gilpin*. An admirable Indian hunter named Joe Glode, once shot a moose in Annapolis County. Not having a knife, he immediately took the flint from his gun, and without more ado, bled and dressed the carcass therewith. Lescarbot, in a sentence before quoted, mentions the occasional use of a stone in fashioning arrow-shafts.

B.—PECKED, GROUND, AND POLISHED STONE.

Polished Stone Hatchets or Celts, and Adzes—These two groups I have classed together, for although the tools I shall here describe are usually termed celts or, more correctly, stone hatchets, in most archæological books, yet after a careful examination of a great many specimens found in this province, I have come to the conclusion that nearly all of those specimens, in form or otherwise, bear evidence of having been used as adzes, mostly hafted to wooden handles in the manner still or until recently exemplified in the stone implements of the South Sea Islands and elsewhere. This was accomplished in the following manner. A branch of sufficient stoutness was obtained, together with part of the stem from which it sprang. The stem portion was then split, forming a flat surface, and the superfluous wood having been trimmed therefrom, the flat portion was applied to the face of the stone tool which was then lashed to it by means of raw-hide thongs or possibly withes. Owing to the tapering form of the stone head, every blow would tend to tighten the hold of the binding. A piece of skin was perhaps interposed between the handle and the stone, as the Indians of Dakota have been known to do in fashioning their bone hoes or adzes.† There cannot be a doubt that most of the

* "Stone Age of Nova Scotia." *Trans. N. S. Inst. Nat. Sc.*, vol. iii.

† See Rau, *Archæological Collection of U. S. National Museum*, p. 95, fig. 334, etc.

specimens, hereafter to be described, were so hafted and used as adzes, their form making it very manifest. Some may have been encircled a couple of times with the central portion of a withe, the ends of which when bound together would form an adze-handle, but one not so convenient as that just described. Occasionally they may have been held directly in the hand, and used as an adze, but I do not think it is at all probable.

The evident adze-like form of so-called celts or polished stone hatchets found in Nova Scotia, has been largely or entirely overlooked by writers upon the subject; neither Dr. Gilpin nor Dr. Patterson having paid sufficient attention to this most interesting fact. To me it seems of much importance. Scarcely a "celt" can be found which does not give rise to a suspicion that it had been used as an adze. Further attention will be drawn to this in the pages which follow. Our Indians, like some oriental peoples, seem to have preferred a drawing cut or one made toward the body. This is very evident and remarkable in the present drawing-method in which the Micmacs use their home-made steel knives, a method which is entirely at variance with the practice of those about them.* This of course is the survival of a very ancient habit, and must not be lost sight of by investigators.

In answer to an inquiry upon the subject, Dr. Bailey tells me that in all New Brunswick celts there is a difference of curvature on the two sides—one being flatter than the other; but the amount of difference varies a good deal, and in some cases is hardly perceptible.

Mr. David Boyle, whose name is prominent in Canadian archæology, also writes me that about nine-tenths of the "celts" found in Ontario are flat, or comparatively flat, on one side, which is more or less indicative of their having been adzes. One thousand stone axes or adzes, at least, are in the museum of the Canadian Institute, of which Mr. Boyle is curator.

He furthermore mentions a significant fact which shows how prevalent among the Eskimo is the adze method of hafting. "It

* It resembles a good deal the manner in which a blacksmith uses his knife for paring hoofs.

has been recently observed," he writes, "that when European hatchets have been given to these people, they invariably take out the handle and attach another sidewise, by binding it with thongs or sinews through and around the eye."

Murdoch also says that the Indians of the north-west coast of America always re-haft as adzes any steel hatchets which they obtain by trade. In some cases they even go to the great trouble of cutting away parts of the implement in order to better adapt it to the new method of use.*

Lieut. T. Dix Bolles in his catalogue of Eskimo articles collected along the north and north-west coast of America, mentions no axes among the many thousands of objects noted. There were, however, twenty adzes, eighty-seven adze-blades, and eleven adze-heads. Dr. Wilson, of the U. S. National Museum, says that the same condition exists all down the coast to Lower California, no stone tools—save in one instance—having been found which undoubtedly had been used axe-wise.†

Among certain tribes, I understand a grooved implement is found which is used as an axe, but among the Eskimo it is replaced by the grooved adze. The line between these two implements is now being investigated. *Does the prevalence of the adze-form in Nova Scotia indicate in any way the influence or presence of the more northern race?*‡ There is evidence to show that the latter people once inhabited the country much to the south of the region in which they now dwell, and the Micmacs at one time waged war upon them, as described by Charlevoix.

To return once more to the form and use of the so-called celts found in Nova Scotia, it may be said that the few speci-

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* See John Murdoch in *Ninth Annual Report U. S. Bureau of Ethnology*, pp. 165-166, and figs. 128-129.

† See Lieut. T. Dix Bolles, "Preliminary Catalogue of Eskimo Collection in U. S. Nat. Museum," in *Report of Nat. Mus.* for 1887; also Dr. Thomas Wilson, "Stone Cutting Implements," 4th paper, in *The Archæologist* for June, 1895, (vol. iii, p. 179.)

‡ I would like to draw particular attention to the possibility of many of our prehistoric remains being relics of the occupation of the country by Eskimo, previous to their having been driven northward by the Micmacs. The latter belong to the Algonquin family, and doubtless pressed to the north in accordance with the general direction of migration in the east. The significance of the form of Nova Scotian stone implements as bearing upon the question of the occupation of the land by a northern race, has not, I think, before been noted by writers.

mens which are not distinctly more convex on one side than on the other, possibly were inserted in clubs or used as hatchets. With a wooden mallet they could be used without a haft as wedges to split wood, which might sometimes be necessary; but they could never be struck with a stone hammer as some suggest. The more common adze-like form, however, was well adapted for very many uses to which it might be put by savage man, such, for instance, as clearing away the charred wood in the process of forming various hollow vessels by the action of fire, cleaning fresh skins of adhering particles of flesh, and numerous other operations. Lescarbot mentions that the Armouchiquois (Indians inhabiting what is now called New Hampshire and Massachusetts), Virginians, and other tribes to the south, made wooden canoes by the aid of fire, the burnt part being scraped away "with stones."

Thirty-eight of these so-called celts or adzes, either complete or fragmentary, are in the Fairbanks collection (Figs. 17-54), and nearly all show some indications of the adze-form to which I have drawn attention. This will be seen by reference to the side views of the implements shown in the accompanying plates. In size they vary from 4·50 to about 11·75 inches in length. All taper more or less toward the butt or end farthest from the edge. The latter is nearly always much rounded, producing a gouge-like cut, well suited to such uses as forming hollows in wood, dressing skins, etc.

Two typical specimens may be selected in order to exemplify differences in form. The first (Fig. 17) which illustrates the *broader form*, measures nearly 7·50 inches in length and 3·25 in width near the cutting edge, thence tapering to 2·10 in width close to the butt, where it rounds off. The greatest thickness is 1·60 inch. The implement has been intentionally formed somewhat flatter on one side than on the other. This is quite noticeable. The flattened side is more polished than the other, probably from the friction of a haft.

About eight or nine specimens resemble this form pretty closely, a few others less so (Figs. 17 to 30). One (Fig. 25) is

nearly 11 inches long by 3·25 in greatest breadth, and weighs 57 ounces. Another specimen (4·50 × 2·25 × ·75 ins.) is formed of a greenish-tinted stone, fine in texture, and capable of bearing an excellent polish and a fine edge (Fig. 19). It differs in material from all other specimens in the collection, but resembles in this respect, as well as in shape, a small felsite implement from Summerside, P. E. I., which is described in my paper on the aboriginal remains in the Provincial Museum.

To illustrate the second or *more elongated form*, I shall take a fine, well-formed specimen (Fig. 31), the production of which must have cost its maker much skilful labour. It was originally about 11·75 inches long, but an inch of the end bearing the edge has been broken off. At the broader extremity, it measures 2 inches in width, from which it tapers gradually and gracefully until it measures 1·20 in breadth at the butt. The thickest portion—about 4 inches from the cutting edge previous to being fractured—measures 1·25, from which it becomes rapidly thin in order to form a sharp edge, and very gradually thinner toward the opposite end or butt. Its weight is about 26 ounces. One side of the tool is almost perfectly flat, contrasting greatly with the rounded form of the other side. In the present specimen and some others which resemble it in this respect, the central line of elevation from end to end, on the convex side, is very noticeable and adds not a little to the beauty of the implement; others are more regularly rounded and do not exhibit this ridge. A section at right angles to the length would be plano-convex in outline. The specimens which most nearly resemble this typical one, have the edge very much rounded or nearly semicircular, and so produce a deep cut like that made by a gouge.

Some twenty specimens (Figs. 31-50)—eleven of them being parts of broken implements—may be described as evidently of this form, and a few others resemble it more or less. They are without the slightest doubt adzes, and are more plainly adze-like in shape than those of the first type. Both forms grade into each other.

One incomplete specimen of the second type bears a longitudinal groove on the flat side, extending to within nearly 2·50 inches of the cutting edge (Fig. 46). I have never before seen a groove thus cut on a Nova Scotian implement of this kind. It may have been intended to lodge the crooked portion of a handle, thus gaining greater firmness, or possibly it once extended so as to form a gouge at the missing end, as remarkably instanced in two gouges referred to hereafter. The latter explanation, however, does not seem probable. It may be that the tapered end or butt having been broken off, the groove was formed in order to again haft the remaining part in the manner just suggested; otherwise the re-hafted fragment would doubtless have slipped in its lashings. A short transverse groove, however, would have answered the purpose, and probably could have been more easily made.

A well-formed specimen (Fig. 47) of the second type, proportionately broader than other implements of the kind, has a boss near the middle of the convex side, which would help to retain the lashing in place. At the point of the butt there is a slight prominence for the same purpose. This is additional evidence of the adze method of hafting. An implement of the first or broader type, exhibits a similar knob on the same side, near the butt (Fig. 22). A gouge (Fig 63) in the collection also has two well-defined bosses, one near the butt and the other near the middle. One or two other gouges have slightly raised transverse ridges for the same purpose. This indicates that some form of gouges, at least, were hafted like adzes.

A couple of implements resembling the second type, are somewhat rectangular in transverse section (Figs. 49 and 50). A thin celt, 6 inches long and ·65 of an inch thick, shown in Fig. 51, was possibly used as a chisel. Two other specimens (Figs. 53 and 54), measuring respectively 11·25 and 12 inches, are very rough. One, palæolithic in appearance, is merely chipped into form. The other (Fig. 53) is doubtless a natural form, and would have been rejected from the present account were it not for indications that the larger end had been artificially brought

to an edge. These two implements may belong to an older period than those of finer workmanship.* Attention has recently been drawn to supposed evidences of a palæolithic age in America, and Prof. Thomas Wilson of the Smithsonian Institution has dealt with the subject in a paper entitled "Results of an Enquiry as to the existence of Man in North America during the Paleolithic Period of the Stone Age" (*Report U. S. National Museum*, 1887-88) which has been referred to on a previous page. Collectors in Nova Scotia should search closely for the ruder forms of implements, which from their apparently unwrought appearance may have hitherto escaped notice.

The collection contains an interesting implement which possibly is an adze (Fig. 55). It measures 10·50 inches in length, 2·50 inches in breadth near the cutting edge, and 2·15 at the butt, and its greatest thickness is about 1·70. It is elliptical in section; and does not appear to be noticeably more flat on one side than on the other. The cutting edge is battered and very dull, and the butt is somewhat shattered from a blow. What makes it particularly remarkable, is a slight groove which encircles it entirely, a little more than six inches from the cutting edge. Just above the groove are two prominences or shoulders, one on each lateral edge of the tool, and from thence to the butt the edge is slightly hollowed; all of which would assist in the attachment of a handle. I do not remember ever to have seen a similar example from Nova Scotia. It forms a link between the celt or adze and the ordinary grooved axe.

Besides the celts or adzes in the collection just referred to, some other undescribed examples which have come to my notice may be here described.

The McCulloch collection contains eight specimens (Figs. 84, 85, 87-92), all presumably from this province. Two (Figs. 89 and 90) are fragmentary, the rest entire. About five of them (respectively 10·50, 9·50, 7, 6, and 4·75 inches in length) may be likened to the first or broader type (Figs. 84-85, 87-88, 92). One of these (4·75 × 2·25 inches), showing the transition to the grooved axe,

* A few rude celts in the Provincial Museum resemble the two described above.

is slightly indented on the two lateral edges midway in the length (Fig. 92). This was for the purpose of holding the lashing which bound the haft adzewise. It agrees in size and shape with a syenite implement in the Provincial Museum, a description of which will be found in a previous paper.* The adze-like form is more or less noticeable in the specimens in the McCulloch collection. It is difficult to decide to which type the two fragments belong. The collection also contains an extremely small and frail "celt" (Fig. 91)—the most slightly proportioned one which I have seen. It is not quite 4·25 inches long, an inch in greatest breadth, and ·50 of an inch in greatest thickness.† Its form is very symmetrical. Possibly it was intended for the use of a child, or else for some finer work than that for which the larger tools were adapted. In the Fairbanks collection, the shortest complete specimen, which is distinctly of the second type, measures a little more than 5·25 inches in length (Fig. 35). An implement (Fig. 86), eight inches in length, found near Margarie, Cape Breton, has been shown to me by E. C. Fairbanks, Esq., of Halifax. It is evidently an adze, and belongs to the broader form.

From my examinations of Dr. Patterson's large collection in the museum of Dalhousie College,‡ I find that nearly every so-called celt or axe therein, exhibits, more or less distinctly, one side which is intentionally more convex or rounded than the other; which, with other occasional indications, tends to raise a suspicion that they had been used as adzes. An adze (No. 40) in that collection, labelled a "stone axe, Middle River Pt., Pictou Co." (length 9·50 inches, greatest breadth 2·65), still retains the worn places, on the flatter side, made by contact with the adze-handle. Indications of this are also to be found in other instances. No. 53 in the same collection, labelled a "celt or

* Aboriginal Remains of N. S., *Trans. N. S. Inst. Nat. Sc.*, 1st series, vol. vii, p. 282.

† In my paper mentioned in the above note, the measurements of three "celts" were misprinted as much shorter than this. The figures in lines 17, 18. and 22, page 280, of that paper, should respectively read 4·90, 4, and 4·90 inches.

‡ A full description of this excellent collection will be found in Dr. Patterson's paper on "The Stone Age of Nova Scotia," *Trans. N. S. Inst. Nat. Sc.*, series I, vol. vii.

chisel," is nearly flat on one side, while around the other side is a depression or shallow groove wherein where lodged the thongs which bound it to an adze-haft. In nearly every case the cutting edge is more or less rounded; very rarely is it nearly straight. Indications of the prevalence of the adze-form of tool, are very frequent, and in many cases they leave not a doubt as to how the implement was used. In an axe or hatchet the flat side would have little or no advantage, except that it would allow the tool to lie closer to the wood in making cuts in one direction.

Chisels.—There is no implement before me which I care so to designate, although one thin celt, before mentioned, might be so considered by some (Fig. 51). It seems doubtful whether our Indians ever used an implement in the manner in which we handle a chisel. A hafted implement for striking blows would be far more useful to a savage people.

Gouges.—Dr. Rau, in his description of the archæological collection of the U. S. National Museum, says that these implements occur in the United States far less frequently than the celts, and that they appear to be chiefly confined to the Atlantic States. The latter circumstance suggests that the work in which they were employed, was principally necessary or possible in the country bordering the eastern coast. They may have been used in making canoes, but we would then expect to find them abundant on the Pacific Coast, unless another implement was there applied to the purpose, which is quite likely. Their employment by certain tribes may account for their more frequent occurrence in particular parts of the continent. Of course it is not probable that all gouges were put to the same use. Doubtless many of them, perhaps even all, were hafted adzewise, and employed in forming hollows in wood which had previously been charred by fire and so rendered capable of being worked by such fragile tools. They would thus be useful in making wooden canoes, or in fashioning various utensils from the same material. I cannot agree with those who consider that some of these easily-destructible implements (those with the groove from end to end) were employed in tapping and gathering

the sap of the rock maple. Surely the axes or adzes were well adapted to making the requisite incision in the bark, and this having been done, a piece of birch-bark, always available, was without doubt employed to conduct the fluid so it should fall into a receptacle beneath. Dr. Gilpin also was mistaken in supposing that gouges, etc., were used in making arrow-heads. We must never lose sight of the fact that the Indian had a fragile material from which to form his tools, and he had therefore to handle them with much care. The fair, and frequently very excellent state of preservation in which we find the edge of most cutting implements, shows that they were not often taxed beyond their strength.

Seventeen gouges are in the Fairbanks collection (Figs. 56-72). In length the perfect specimens vary from 5.50 to 10.50 inches. With perhaps one or two exceptions, all taper more or less toward the extremity furthest from the crescent-shaped edge. The one which most plainly exhibits this tapered form, measures 2 inches in width near the latter edge, and thence tapers regularly to a small rounded end at the other extremity; its total length being 6·50 inches (Fig. 63). These implements are often of noticeable symmetry, and probably were once well-polished. They are formed of stones of only moderete hardness.

The extent of the groove which gives them their characteristic form, varies much. Such variations, doubtless indicate different uses to which the tool was to be put.

In some, the *groove is almost entirely indistinguishable* and confined to the vicinity of the cutting edge. They thus pass gradually into the adze-form, which this tool otherwise greatly resembles. Three or four of the gouges before me, are of this unpronounced shape (Figs. 56-58, 60). They vary from 8·50 to a little more than 6 inches in length.

Six specimens have the *groove extending about half the length* (Figs. 59, 61-65)*. They vary from 6 to 10·50 inches in

* A specimen (Fig. 93) in the McCulloch collection, Dalhousie College, differs a little from typical examples of this form, and slightly exhibits the transition to that in which the groove extends throughout.

length. Another specimen of this kind is in my own collection, and was found at Waverley, near Dartmouth, by Mr. Skerry (Fig. 94). It, together with three of the six just mentioned, are wide and exhibit a very deep, broad groove. Another, narrow and 9 inches long, is very interesting (Fig. 64). Although the groove is quite evident and extends for half the length, yet the end of the tool bears no cutting edge, that portion being blunt. The other extremity, however, has been rubbed into a narrow adze-like edge. The implement may be a disabled gouge which had been altered into an adze; the gouge groove, having been utilized as a convenient resting place for the T-shaped portion of a handle, which was then whipped round with thongs. Or possibly the groove may have been intentionally made in order to assist in maintaining the position of the haft. Another specimen (Fig. 65) much resembles the one just described, but the gouge-edge is less blunt. Both may have been hafted in the middle like a modern pick-axe, and so used both as a gouge and and as an adze; but this is not probable. As a slick-stone for dressing skins, the combination of two forms would not be without advantage. The fragment of an adze-like implement (Fig. 46) which has been referred to in my description of polished stone hatchets and adzes, resembles the two tools I have just noticed, inasmuch as although the edge is undoubtedly adze-like in shape, yet the upper portion of the fragment bears a shallow but distinct groove. Among the specimens in the cabinet of the Canadian Institute, Toronto, is an implement having a gouge at one extremity and a chisel at the other. It was found in Simcoe County, Ontario, and will be found figured in the report of the Institute for 1891, page 38.

An examination of at least three gouges (Figs. 61, 63, 94,) of the second or half-grooved form, puts it beyond doubt that these three were hafted like adzes, with the concavity facing the user. My own specimen (Fig. 94) from Waverley shows plainly on the convex side two ridges for retaining the lashing, and another (Fig. 63), well proportioned, exhibits two prominent nodules for the same purpose. One or two adze-like "celts" bear similar

nodules (Figs. 47 and 22). Probably many other gouges were thus hafted. Without doubt it was the most reasonable method of handling these tools when delivering excavating blows.

We shall now pass to those gouges in which the *groove extends throughout the entire length*. Five well-defined examples (Figs. 66-70) are in the Fairbanks collection, together with two (Figs. 71, 72) which are rough and very poorly formed. The groove varies in depth from about ·09 of an inch (Fig. 72) to more than ·50 of an inch (Fig. 66), and in width from a little over ·75 to nearly 1·50, Three of the five well-formed examples are fragmentary, having been transversely broken near the middle. The adze-like manner of hafting would not be quite so well adapted to this particular form.

Grooved Axes.—These implements are rarely found in Nova Scotia. Dr. Patterson has succeeded in obtaining but one specimen (7·25 inches long by 3 25 wide) which was discovered at St. Mary's, Guysborough County. Two examples are in the Provincial Museum, Halifax, and have been previously described.* One of them is double grooved. In this respect it is probably unique in Nova Scotia. The second groove was very likely formed in order to shift the haft and so improve the balance of a faulty implement. These, together with the examples which I am about to describe, are all which have come to my notice in Nova Scotia. It is quite possible that they were only introduced through trade with other tribes or as trophies of war. They are also rare in Ontario as compared with Ohio, Kentucky, and some neighbouring states. Dr. Bailey informs me that of six axes in the museum of the University of New Brunswick, Fredericton, four are grooved, and he has seen others of the same kind in the St. John collection and elsewhere in that province.

Two well-formed, perfect specimens (Figs. 73-74) each with a single groove, are in the Fairbanks collection. They agree in outline and general proportions, and their form may be considered typical. The larger one (Fig. 73) is 7·50 inches long and 4 inches in greatest width, and weighs 49½ ounces. The smaller

* *Trans. N. S. Inst. Nat. Sc.*, vol. vii., p. 282.

one is 6·75 inches in length and 3·75 in greatest breadth, and weighs 40 ounces. Both appear to have been formed from oval quartzite boulders such as are found on beaches. From near the groove, to the edge, they are neatly "pecked" into shape, while the whole of the butt, above the groove, is smooth, being evidently the original surface of the boulder. The aboriginal worker in stone, was doubtless always ready to take advantage of such material as nature had already partially shaped, thus lessening his labour. The edges do not show signs of rough usage. The butt of the smaller one is intact, but that of the larger bears the marks of many light blows which probably were the result of its use in cracking bones in order to extract the marrow.

These axes could have been employed in detaching birch bark and in girdling trees and so killing them preparatory to felling them by the aid of fire, the axe being again used in order to remove the charcoal as it formed. The tool would also constitute a formidable weapon. Prehistoric man made his few implements answer as many purposes as possible.

An axe very similar to those I have described, is figured by Dr. Rau (*Archæological Collection of U. S. National Museum*, figure 72). It was found in Massachusetts. I have never seen a Nova Scotian axe with the groove only on three sides, as shown by that writer in figure 73 of his work.

Hammers.—A beautiful hammer-head (Fig. 95) is in my own collection. It is formed from an egg-shaped boulder, very slightly compressed on opposite sides. Its length is 3·50 inches, greatest breadth 2·50 inches, and its weight a little more than 19 ounces. Midway from either end, it is entirely encircled by a "pecked" groove, which has not been smoothed by friction. This groove was formed in order to attach a handle. Its roughened surface would tend to increase the hold of the haft and its lashings, and the interposition of a piece of hide, which was quite probable, might account for the absence of any smooth surfaces in the groove. Each end shows distinctly the denting marks of numerous blows, but there are no large fractures. This

condition of the ends and the formation of the groove, are evidences of the hand of man, but the oval shape of the stone is the work of natural agencies, perhaps slightly improved by the skill of the aboriginal craftsman. The implement was probably used as a weapon in time of war, while in the peaceful occupations of savage life, it was put to any uses to which it was adapted.

Grooved stone hammers are very rare in Nova Scotia, in truth I do not remember to have met with another. They are also, I believe, rare in the neighbouring province of New Brunswick. My specimen was found in July, 1894, while the foundation was being dug for a manse, two or three rods to the northward of St. James's Presbyterian Church at Dartmouth. A great number of human skeletons have been unearthed at that spot, but after careful inquiry and personal search for anything which might serve to identify those who are there buried, I have only succeeded in obtaining this hammer and a linear-shaped piece of iron, 9·50 inches long, which I think must have been a dagger-shaped implement, or possibly a spear-point. A second iron relic of the same kind was discovered, but I did not see it. The bones were from one foot to two and a half or three feet below the surface of the ground. In one instance I succeeded in finding the remains of a nailed wooden box or rough coffin. It was almost entirely disintegrated and chiefly appeared as a dark-coloured line in the soil. The grooved-hammer was found close to one of the skulls. After a good deal of investigation, I have come to the opinion that there is no evidence whatever to to show that this was an Indian cemetery, except the presence of the above-mentioned relics. Those who are buried there, are doubtless white men. The theory that they were the victims of the massacre at Dartmouth in 1751, cannot be maintained. Various reasons make me strongly of the belief that this spot bears the bones of many of the Duc d'Anville's plague-stricken followers, others of whom were interred near the shores of Bedford Basin. For further information on this point, the reader may refer to a footnote on page 6 of Mrs. Lawson's History of

Dartmouth. It is known that the Micmacs assembled about the French camp, and the presence of an Indian implement in the burial-ground of their allies is not to be wondered at. The weapon may even have been placed in one of the coffins as a savage mark of respect for the alien dead.

Pendants and Sinkers.—Two well-formed specimens of this class—one perfect, the other nearly so—are in the Fairbanks collection (Figs. 75-76). They are both somewhat pear-shaped and much resemble plummets. The lower extremity is pointed, and the upper end expands into a knob to facilitate suspension. They thus resemble figure 106 in Dr. Rau's description of the archæological collection of the U. S. National Museum The larger one (Fig. 76) is formed of dark red sandstone, and measures four inches in length. The greatest diameter is toward the lower end. The other is made of a dark hard stone. Its length is three inches, and the largest part is situated about midway between the ends. It is not so elongated as the other example. The two sides, including the knob, are somewbat compressed, thus making the diameter 1·40 inch in one direction and 1·70 in the other.

A third "sinker" (Fig. 80) has been kindly lent me by W. C. Silver, Esq., of Halifax. It was found in the bed of the Salmon River, adjoining that gentleman's property at Preston, about seven miles to the east of Halifax. He informs me that the place where it was discovered was an old spawning ground. The specimen is a very beautiful and perfect one, fashioned with great pains from a reddish stone, like sandstone, containing small particles of mica. Its length is 3·25 inches, and its greatest diameter (1·20 inch) is near the upper end or point of suspension. The groove just below the knob at the top, is distinctly smoothened by a thong by means of which it must have once been suspended. The discovery of the stone in a river, tends to strengthen the view that it had in some way been employed in connection with fishing. Whatever may have been its use, it shows what skilful work our Indians bestowed upon the manufacture of some of their implements.

These so-called "plummets" or "sinkers" are very rare in Nova Scotia, Dr. Gilpin figures one in his paper on the stone age. There are but two in the Patterson collection: one, 3·75 inches long, well-shaped, with a pointed lower end, being from Annapolis County; the other, two inches long, quite light in weight, with a rounded end, from Lunenburg County. There are none in the collection in the Provincial Museum. Dr. Bailey in his "Relics of the Stone Age in New Brunswick," figures four or five which had been found in that province.

It is worthy of remark that the sides of such specimens as I have examined, exhibit more or less a tendency toward compression, as has been already noted of one example. This slightly flattened form was probably intentional. Dr. Patterson's Annapolis "sinker" has been ground down in one or two places on the side, but I have not found any others in this condition. I may say that although all specimens are carefully fashioned, and of the same general appearance, yet they differ much among themselves in detail of form. In no case have I noted any with a hole for suspension, although such would have been a more secure method of hanging them had they been used as weights for fishing-lines.

These pear-shaped objects have long perplexed archæologists who have attempted to define their use. We find them variously denominated sling-shots, sinkers for fishing-tackle, stones used in playing some game, personal ornaments, sacred implements for performing some religious ceremonies, plummets, spinning-weights, etc.

In a paper entitled "Charm Stones; Notes on the so-called 'Plummets' or 'Sinkers,'" Dr. Lorenzo G. Yates has presented the very interesting results of his investigation into the uses of such implements. For reasons given in the paper, he discards all the stated theories on the subject, except that relating to their employment in sorcery.

A Santa Barbara Indian, California, when asked by Mr. H. W. Henshaw why one of these stones could not have been used as a line sinker, replied with much common sense, "Why

should we make stones like that when the beach supplies sinkers in abundance? Our sinkers were beach stones, and when we lost one we picked up another."

A very old Indian chief, of the Napa tribe of California, told Dr. Yates that the plummet-shaped objects were charm-stones, which were suspended over the water where the Indians intended to fish. A stick fixed in the bank, he said, bore a cord which sustained the bewitched stone. In a similar manner they were employed in order to obtain good luck while hunting. Napa Indians also state that they were sometimes laid upon rocks or peaks, from whence it was supposed they travelled through the water during the night and drove the fish to favourite spots for catching them, or in other cases, drove the game of the woods to the most advantageous hunting grounds.

Other Indians of California say they were medicinal stones, and describe the method in which they were used by sorcerers for curing the sick, bringing rain, extinguishing fires, calling fish up the streams, and for performing ceremonies preparatory to war. A perforated stone was said to make its wearer impervious to arrows.

The above statements may help us to form our own opinion as to the use of these very curious stones in Nova Scotia. Many still hold to the belief that they were sinkers, but most of the evidence seems to be against that theory.

Pipes.—Smoking utensils are somewhat rare in Nova Scotian archæological collections. Only three complete examples, and one in course of construction, are among Dr. Patterson's specimens in the museum of Dalhousie College. Four are in the cases of the Provincial Museum, Halifax, and will be found described in a previous paper by the writer. One of these is probably of European manufacture. Dr. Bailey mentions but a single specimen in his article on the stone-age in New Brunswick. The Fairbanks collection, as now before me, contains no example.

Hon. W. J. Almon, M. D., of Halifax, possesses a large, well-formed pipe (Fig. 96), which is without doubt the most

remarkable one yet found in the Maritime Provinces. The circumstances of its discovery are as follows. In 1870, an upturned copper kettle was unearthed by Mr. John J. Withrow* in a piece of woodland to the westward of Upper Rawdon and within ten rods of the line of an old French trail or road from Shubenacadie to Newport, Hants County. The kettle was about eighteen inches or two feet under the surface. Beneath it, when lifted, were found the stone pipe just mentioned, two iron tomahawks, five or six iron implements about eight or nine inches long, very much rusted, and having a slight prominence near the middle of their length, also about seven dozen oval blue beads ornamented with lines, etc., each bead nearly the size of a sparrow's egg, and lastly a tooth which seems to have been the curved incisor of a beaver. There were no human bones or other indications of a burial. The five or six iron implements Mr. Withrow thinks were knives, but they were so corroded as to make identification very difficult or impossible. The kettle was fifteen inches or so in diameter and about nine inches in depth, and it had a handle for suspension. Close to where the kettle was found, was a hemlock, two feet in diameter. With the exception of a few of the beads, which Mr. Withrow retained, the relics subsequently belonged to J. W. Ouseley, Esq., barrister of Windsor. Half of the beads were given by this gentleman to the late Judge Wilkins, the remainder are still in his possession. Dr. Almon obtained the pipe from Mr. Ouseley.

The bowl and stem of this splendid example of aboriginal skill, are formed of one piece, thus somewhat resembling a clumsy modern clay pipe. The intervening portion forms a curve. The most noticeable feature of the article is a bold representation of what is undoubtedly a lizard, placed with its ventral surface on that side of the bowl which is farthest from the smoker. The fore and hind legs clasp the bowl, while the long tail lies upon the lower surface of the stem. The broad head extends upward beyond the rim of the bowl. Two dots at the extremity of the somewhat pointed snout, represent the

* Now of South Uniacke Mines, Hants County, N. S.

nostrils of the animal. The mouth is closed, and reaches around to the side of the head, beneath the eyes. The latter are represented by large, well-defined, circular cavities. Across the back of the neck appear a row of five elliptical cavities, their greatest length being in the direction of the length of the body. The long fore-legs are bent upwards at right angles, and the toes rest on the sides of the bowl's rim. Incised lines divide the fore-feet into rather long toes, seven of which are on the right foot. The hind legs are shorter, slightly broader, and are gradually lost in the contour of the bowl, without any indication of toes. A longitudinal line extends from the thigh to the vicinity of the hind foot. A round hole, about ·25 of an inch in diameter, is drilled from side to side of the bowl, at the ventral surface of the lizard and just anterior to the hind-legs. This hole was doubtless for fastening the pipe, by a thong, to the smoker's dress, in order to prevent its being lost or broken; or else for the attachment of an ornament. The rim of the bowl is decorated on top by groups of from four to seven incised radiating lines. The cavity for the reception of the narcotic is nearly circular, and is an inch in diameter. It gradually tapers downward for about an inch and a half, where it is somewhat suddenly constricted to nearly the size of a lead pencil, after which it extends nearly an inch further downward until it meets the perforation of the stem at a little more than a right angle. The total depth of the cavity, therefore, would be nearly two and a half inches. One side of the cavity is continuous with the throat of the lizard.

The length of the stem from the extremity to the edge of the bowl nearest the smoker, is about five inches. Its diameter at the mouth piece is ·40 of an inch; and at the further portion, near the bowl, a trifle more than an inch. The diameter of the perforation at the mouth-end is ·28 of an inch. The bowl rises 1·80 inch above the stem. The thickness of the bowl at the thinnest part, is about ·17 of an inch. Taken generally, the whole pipe may be said to be about seven inches long, but from the mouth-piece to the tips of the figure's snout, it measures 7·60 inches.

The entire specimen is in a very excellent state of preservation, and without a flaw. It is formed of a fine gray stone, different from any found in the province, and closely resembling the material of the remarkable stone tubes in the Provincial Museum (*Vide* "Aboriginal Remains of Nova Scotia;" *Trans. N. S. I. N. S.*, vol. vii.) It bears a fine polish. I did not observe any tooth-marks upon the stem, as would probably have been the case had it always been placed in the mouth without some protective material. A short tube of wood may have originally served as a mouth-piece.

It is a unique specimen in this part of the Dominion. I consider it almost beyond question that it is not the work of Micmacs, but probably came into Nova Scotia as a trophy of war or else by trade with some distant tribe. The stone tubes, just mentioned, probably owe their presence here to the same agency. Trade was not uncommon among the prehistoric tribes, and Lescarbot mentions that our Micmacs, or Souriquois as he called them, greatly esteemed the *matachias*, or strings of shell beads, which came unto them from the Armouchiquois country, or the land of the New England Indians, and they bought them "very dear." Tobacco itself must have been obtained by trading with nations by whom it was cultivated.

Strange to say, in Dr. Rau's account of the collection of the U. S. National Museum (cut 192) is figured a pipe about four and a half inches long, which bears an extremely close resemblance to the Nova Scotian specimen, both in the attitude of the animal upon it and in general shape. Apparently, however, it is much less boldly carved. It was found in Pennsylvania, and is described by Dr. Rau as a very beautiful, highly polished steatite pipe, carved in imitation of a lizard, the straight neck or stem forming the animal's tail, and its toes being indicated by incised lines. The similarity between the two specimens is therefore remarkably pronounced.

Mr. David Boyle, in the report of the Canadian Institute (session 1891, page 29), figures a similar pipe found in a grave in

the Lake Baptiste burying-ground, Ontario. Mr. Boyle speaks of it as exceedingly rare. It is made of a soft "white-stone." The animal whose form extends above the bowl and more than half-way along the stem, he considers was probably intended to represent a lizard.

Mr. Boyle also figures another pipe *(Report Canadian Institute*, session 1886-7, page 29,) which may be likened to our specimen, although the resemblance, owing to the different position of the figure and the absence of a distinct bowl and stem, is not nearly so great as in the two instances we have just given. It was discovered at Milton, Halton County, Ontario. The material of which it is formed is a light-gray stone, very soft and porous, containing minute specks, probably micaceous, and quite unlike anything in the geological formation of that province. The cavities on the body and long tail, resemble those on the neck of the Nova Scotian specimen; they are probably intended to represent spots of colour such as the aboriginal artist had seen on the animal he imitated. Several lizards bear clearly-defined spots of bright colour upon their bodies. Notwithstanding the length of the snout, Mr. Boyle thought that the resemblance of the head to that of a monkey was very striking. I am rather of the opinion that, like the figures on other pipes mentioned, the carving was intended to represent a lizard.

Dr. Almon possesses another stone pipe (Fig. 98), which, although most beautifully ornamented and very symmetrical in outline, is nevertheless of secondary interest, for the reason that it is doubtless of comparatively modern manufacture. It was purchased from a Micmac on the Dartmouth ferry-steamer. In general appearance it closely resembles one found at Dartmouth in January, 1870, described by me in a paper on the aboriginal remains in the Provincial Museum (page 287), or another from River Dennis, Cape Breton, which is figured in the plate appended thereto. This form is considered by Dr. Patterson to be the typical one adopted by our Indians. The bowl, somewhat barrel-shaped, rises from a base, laterally flattened. In the

present specimen, this flattened base or keel, when viewed sideways, is square, not lobed, in outline, and below the centre it contains a round hole for the suspension of an ornament or to facilitate attachment to the owner's dress by means of a thong. The bowl and keel are most tastefully ornamented with single and double straight lines, dots, very short diagonal dashes, and conventional branches of foliage, all arranged in neat designs which entitle the carver to much credit for his excellent work. I have never seen a more comely Micmac pipe. The style of ornamentation much resembles that of a very graceful pipe of fine argillite which belongs to my father, Henry Piers, Esq. This, for the sake of comparison, I have illustrated in Fig. 97. It was made by a Maliseet Indian of New Brunswick, and bears the date March 5th, 1859. The figure on the fore part of the bowl is excellently carved, and represents a long-haired Indian, seated, with arms across his breast. The other decorations manifest much taste on the part of their swarthy designer.*

Dr. Almon's specimen, last referred to, is made of a blackish stone, probably a close grained argillite. The total length is nearly 2·50 inches; and the height of bowl, 1·40. It is in a fine state of preservation, and everything seems to indicate that it was formed with modern metal tools. Possibly it is not a century old.

Dr. Almon's lizard pipe and the flat-based specimen from Musquodoboit in the Provincial Museum, are the most interesting examples of this class I have yet seen in our province. Neither, however, are to be considered as typically Micmac.

Incertæ sedis.—Three specimens, which cannot be treated under any of the preceding heads, yet remain to be described. A

* The half-tone plate does not show with sufficient distinctness the designs on the pipes represented in Figs. 97 and 98. M. Lescarbot says that "our Souriquois [Micmacs] and Armouchiquois savages have the industry both of painting and carving, and do make pictures of beasts, birds, and men, as well in stone as in wood, as prettily as good workmen in these parts; and notwithstanding they serve not themselves with them in adoration, but only to please the sight, and the use of some private tools, as in tobacco-pipes." [Book II, chap. v.]

singular, roller-shaped object, presumably of aboriginal workmanship, which I find in the McCulloch collection, is shown in Fig. 79. The ends have evidently been cut off while the stone was rotating. Another curious object (Fig. 78) is in the Fairbanks collection. One face thereof is slightly hollowed, while the other is correspondingly convex. The wider end has been partially cut away so as to leave a short neck. I shall not venture an opinion as to the use of these two relics. An oval boulder (Fig. 77), very regular in shape, is in the same collection. Not the slightest importance, however, can be attached to it, for it is merely a natural form bearing no marks of man's workmanship.

EXPLANATION OF PLATES I. TO III.

Scale: Figs. 1-16, 96-98, two-sevenths natural size; Figs. 17-95, one-seventh natural size.

Fig. 1-11. Arrow-heads.
12-16. Spear-heads or cutting implements.
17-54. Adzes and celts.
55. Grooved axe or celt (?)
56-72. Gouges.
73-74. Grooved axes.
75-76. Pendants or sinkers.
77. Oval stone.
78. Stone of unknown use.

Fig. 79. Roller-shaped stone.
80. Pendant or sinker.
81-83. Spear-heads or cutting implements.
84-92. Adzes or celts.
93-94. Gouges.
95. Hammer.
96. Lizard pipe.
97. Maliseet pipe.
98. Keeled pipe.

V.—PHENOLOGICAL OBSERVATIONS MADE AT SEVERAL STATIONS IN EASTERN CANADA DURING THE YEAR 1894.—COMPILED BY A. H. MACKAY, LL.D., HALIFAX.

(Read 13th May, 1895.)

The observations conducted under the auspices of the Botanical Club of Canada for 1894 are more complete and extended than those published the previous two years. The observers to be credited with this work at the various stations are the following:

Yarmouth, N. S.—Miss Antoinette Forbes, B. A.

Shelburne, N. S.—Mr. Angus McK. Swanburg.

Halifax City, N. S.—Mr. Harry Piers.

Musquodoboit Harbor, N. S.—Rev. Jas. Rosborough.

Berwick, N. S.—Miss Ida Parker.

Wolfville, N. S.—Prof. A. E. Coldwell, M. A.

Port Hawkesbury, C. B.—Miss Louise M. Paint.

Antigonish, N. S—Prof. MacAdam, M. A.

Pictou, N. S.—Mr. C. B. Robinson, B. A.; Mr. W. A. Hickman.

Wallace, N. S.—Miss M. E. Charman.

Charlottetown, P. E. I.—Principal J. MacSwain.

Grand Harbor, Charlotte Co., N. B.—Mr. Henry D. Perkins.

Richibucto, N. B.—Miss Isabella J. Caie.

Dalhousie, N. B.—Mr. Alex. Ross, B. A.

Winnipeg, Manitoba.—Rev. Wm. A. Burman, B. D.

Tables B. and C. are given merely as specimens of inductions which can be made from Table A, or the series of such tables for a few years.

TABLE A.—PHENOLOGICAL OBSERVATIONS FOR 1894

Giving the day of the year (by number) of the first appearances of each column of the table below. Last day of Jan., 31; Feb., 59; Sept., 273; Oct., 304; Nov., 334; Dec., 365.

Number.	PHENOMENA.	Yarmouth, N. S.	Shelburne, N. S.	Halifax, N. S.	Musquodoboit Harbor, N. S.	Berwick, N. S.
1	Alder. Shedding pollen	113	107	112	119	119
2	Aspen "	....	120	....	....	123
3	" Leafing out	....	140	....	....	147
4	Red Maple. Flowering	120	118	137	134	115
5	Hepatica. "	....	...	....	....	128
6	Adder's Tongue Lily. Flowering	....	....	....	....	138
7	Mayflower. "	69	104	74	110	...
8	Dandelion. "	112	124	137	137	132
9	Strawberry, (wild). "	114	124	133	138	128
10	" (cultivated). Ripe Fruit	156	....	167	...	162
11	Cherry, (cultivated). Flowering	....	....	....	....	140
12	" " Ripe Fruit	...	....	....	....	196
13	Wild Red Cherry. Flowering	142	121	155	155	132
14	Indian Pear. "	138	131	142	149	...
15	" Ripe Fruit	....	....	....	....	..
16	Apple, (cultivated). Flower	144	....	....	162	143
17	Oaks. Flowering	175	....	...	....	152
18	Hawthorne. Flowering	168	156	170	170	159
19	Lilac. "	163	....	169	170	153
20	Raspberry, (wild). Fruiting	....	....	211	...	196
21	Wheat, (Spring). 1st sewing	....	....	....	....	..
22	" Harvesting	....	....	....	....	237
23	Song Sparrow. 1st Appearance	....	....	90	....	98
24	American Robin. "	60	79	74	....	61
25	Spotted Sandpiper. "	....	...	144	....	124
26	Swallow. "	109	109	116	....	110
27	Kingfisher. "	....	118	133	....	112
28	Hummingbird. "	137	....	....	....	136
29	Night Hawk "	....	....	144	....	140
30	Wild Ducks. First Birds	....	....	....	....	100
31	" First Flock	....	....	68	....	100
32	" Migrating South	....	....	....	....	258
33	Wild Geese. First Birds	....	....	....	....	...
34	" First Flock	82	....	....	....	...
35	" Migrating South	....	....	....	....	337
36	Frogs' heard	96	106	112	....	108

IN THE ATLANTIC PROVINCES AND WINNIPEG.

leaf, flower, fruit, bird, &c,, at each of the several Stations, above Mar., 90; April, 120; May, 151; June, 181; July, 212; Aug., 243;

Number.	Wolfville, N. S.	Southern Nova Scotia.	Port Hawkesbury, N. S.	Antigonish, N. S.	Pictou, N. S.	Wallace, N. S.	Northern Nova Scotia.	Nova Scotia.	Charlottetown, P. E. Island.	Grand Harbor, Charlotte, N. B.	Richibucto, N. B.	Dalhousie, N. B.	New Brunswick.	Atlantic Provinces.	Winnipeg, Manitoba.
1	...	114	135	...	112	109	118.6	116.3	....	108	....	119	113.5	114.9	......
2	...	121.5	130	...	116	...	123	122.2	....	118	....	122	120	121.1	121
3	...	143.5	155	...	150	...	152.5	148	....	144	....	....	144	146.	134
4	120	124	140	132	123	120	128.7	126.3	....	126	136	134	132	129.1	......
5	116	122	....	...	127	...	127	124.5	....	....	....	....	....	124.5	......
6	133	135.5	....	...	129	...	129	132.2	....	....	....	133	133	132.6	......
7	112	93.8	121	117	110	115	115.7	104.7	124	115	117	....	116	111.2	.....
8	130	128.6	138	127	131	137	133.3	130.9	....	....	....	133	133	131.9	140
9	133	128	140	136	128	137	135.2	131.6	144	131	135	132	132.6	136.1	144
10	...	161.6	186	...	.	171	178.5	170.	....	167	173	....	170	170.	163
11	140	140	156	...	153	149	152.6	146.3	....	....	153	157	155	150.6	......
12	...	196	213	...	...	...	213	204.5	....	....	....	209	209	206.7	......
13	145	141.6	....	154	...	151	152.5	147.	....	157	...	156	156.5	151.8	140
14	139	140	153	152	151	...	152	146.	....	138	....	153	145.5	145.7	140
15	..	.....	223	...	...	...	223	223.	....	....	....	....	....	223.	......
16	149	149.5	165	152	152	150	154.7	152.1	....	161	155	....	158	155.	......
17	157	161.3	....	...	...	...	....	161.3	...	....	....	....	....	161.3	141
18	159	163.6	...	...	...	157	157	160.3	...	....	169	....	169	164.6	141
19	157	162.4	167	161	...	159	162.3	162.3	....	168	161	....	164.5	163.4	......
20	...	203.5	213	...	...	...	213	208.2	....	206	....	202	204	206.1	....
51	...	.....	...	...	...	...	....	....	....	....	....	132	132	132.	106, 131
22	.	237	...	...	...	...	....	237.	....	....	....	250	250	243.5	237
23	70	86	104	..	37	..	71	79.	....	....	....	96	96	87.5	.....
24	77	70.2	87	...	82	60	76.3	73.2	....	....	....	100	100	86.6	105, 112
25	..	134	146	...	127	..	136.5	135.2	....	....	....	153	153	144.1	.....
26	126	114	130	...	118	...	124	119.0	....	107	....	149	128	123.5	147
27	...	121	158	...	115	...	136.5	128.7	....	....	....	....	....	128.7	......
28	137	136.6	150	...	..	149	149.5	143.0	....	....	....	157	157	150.	......
29	...	142	188	...	163	...	175.6	158.8	....	152	....	....	152	155.1	145
30	...	100	....	...	...	...	....	100.	....	....	....	...	....	100.	100
31	..	84	.....	...	...	...	...	84.	....	....	....	....	....	84.	106
32	...	258	263	...	..	...	263	260.5	....	326	...	....	326	293.2	.....
33	...	.....	77	...	68	67	70.6	70.6	....	....	....	89	89	79.8	100
34	..	82	95	...	...	...	95	95.	....	....	....	98	98	96.5	102
35	...	337	....	...	340	350	345	341.	....	....	....	....	....	341.	......
36	111	106.6	125	...	...	113	119	112.8	....	111	....	116	113.5	113.1	113

TABLE B.

AVERAGE OF DATES COMMON TO THE TABLES FOR THE YEARS 1892, 1893 AND 1894.

SPECIES COMMON TO TABLES OF 1892, 1893 AND 1894.	Average date Nova Scotia, 1892.	Average date Nova Scotia and New Brunswick, 1893.	Average date N. S. and N. B., 1894.	Normal for 3 years.	Normal ordinary date.
Alder, flower	102	114	115	110	20th April.
Aspen, 〃	131	123	139	131	11th May.
Maple, 〃	123	130	128	127	7th 〃
Dog-tooth Violet, flower	135	136	132	134	14th 〃
Mayflower, 〃	98	108	108	105	15th April.
Strawberry, 〃	129	133	132	131	11th May.
Cherry, (cult.), 〃	146	142	149	146	26th 〃
〃 (wild), 〃	150	144	150	148	28th 〃
Indian Pear, 〃	145	144	146	145	25th 〃
Apple, 〃	146	146	154	149	29th 〃
Hawthorn, 〃	163	160	163	162	11th June.
Lilac, 〃	154	160	163	159	8th 〃
Song Sparrow	99	115	84	99	9th April.
Robin	96	94	82	91	1st 〃
Swallow	106	119	122	116	26th 〃
Kingfisher	128	137	129	131	11th May.
Humming Bird	143	159	148	150	30th 〃
Night Hawk	150	144	156	150	30th 〃
Wild Goose	54	88	80	74	15th March.
Frog	105	113	113	110	20th April.

TABLE C.

SOUTHERN, COMPARED WITH NORTHERN NOVA SCOTIA.

(Ten Commonly Observed Plants, 1894.)

	Average date, Southern Stations.	Average date, Northern Stations.
Alder, first flowering	114.	118.9
Red Maple, "	124.	128.7
Mayflower, "	93.8	115.7
Dandelion, "	128.6	133.3
Strawberry, (wild), first flowering	128.	135.2
" (fruit)	161.6	178.5
Wild Red Cherry, flowering	141.6	152.5
Indian Pear, "	140.	152.
Apple, "	149.5	154.7
Lilac, "	162.4	162.3
Average dates of the ten	134.35	143.18
Finding the Difference		134.35
Days, Average, Southern Stations are in advance of Northern Stations		8.83

That is, vegetation, as judged from the ten species above, is nearly *nine* days earlier in the South of the Province than in the North.

VI.— A Foraminiferous Deposit from Bottom of the North Atlantic. By A. H. MacKay, LL. D.

(Read 10th December, 1894.)

The exact location of this deposit cannot be more tersely described than it is in the following note from Captain Trott, of the steamship *Minia*, dated Halifax, 31st April, 1894, which accompanied the material sent to Dr. Murphy, Provincial Engineer, who duly passed it on to me.

" Herewith the stones I spoke to you about. They came " from a depth of 2450 fathoms, in latitude 49° 50′ N., longitude " 40° 15′ W. The current in this vicinity runs strong to N. E., " varying sometimes two or three points either way, doubtless " influenced by the moon. The surface temperature ranges from " 54° to 59° Fahrenheit. This is as it is found nearly all the " months of June and July. A little further west we found cold " water and very little current. I am also sending some " *Globigerina* ooze which came up in the same mushroom anchor " with the stones—the anchor being full except on one side " where it had beeu washed out while heaving up, thereby " exposing the stones."

The spot, roughly estimating, is therefore not far from 700 miles south-easterly from Cape Farewell, Greenland, and some 300 or 400 miles east from Labrador, or 300 miles east by north of Newfoundland. This is beyond the Great Banks and well down into the profounder depths of the Atlantic. It would appear then to lie near the circle which, like the circumference of a vast oceanic eddy, lies tangential to the Gulf Stream on the south-east, the westerly Arctic current from Iceland to Greenland on the north, and the southerly Arctic current along the Labrador Coast. The character of the deposit suggests the existence of such an eddy, no matter how circumscribed and swaying its position may be.

The mushroom anchor took up not only a nearly pure stratum of foraminiferous ooze, but also a very clayey foraminiferous stratum, in which were fine and coarse grains of quartz, mica, and other minerals, with pebbles, water-worn, of gneiss, hornblende, black and white limestones. But lavas compact and vesicular were abundant, one specimen weighing over a pound or two. One pebble of dark hard texture is apparently polished on one side, as if abraded by glacial action.

The ooze contracted into a comparatively small volume, say one-fourth, after being kept in a dry room for a few months. Of the more highly foraminiferous stratum, about 50% was sand and clay insoluble in Hydrochloric acid. The equivalent of over 25% of carbonate of lime was precipitated as calcium sulphate from the filtrate. From the more argillaceous stratum 66% of sand, &c., was insoluble in HCl, while H_2SO_4 precipitated but a few grains from the filtrate. This rough analysis was verified approximately by specimens of the two strata analyzed more carefully in the laboratory of Dalhousie College by Mr. J. M. Nissen. The difference between the two strata was sufficiently discernible to the naked eye, and clearly so by a close examination with a simple lens.

The species of foraminifera are fairly numerous. The following list of them has the authority of Mr. F. S. Morton, F. R. M. S., of Portland, Maine, who compared them with the foraminifera described in the *Challenger's* papers and more particularly with those described in a "Synopsis of the Arctic and Scandinavian Recent Marine Foraminifera," by Dr. Alex. Goës of Stockholm. which they more especially resemble. I have also to acknowledge the service of G. F. Matthew, M. A., F. R. S. C., of St. John, New Brunswick, in testing some of my observations.

Globigerina, inflata ....Abundant.
G. dubia ....Not abundant.
G. conglobata ....Not abundant.
Orbulina universa ....Not uncommon.

Sphæroidina dehiscens	Rare.
Pulvinulina menardii	Frequent.
P. micheliniana	Frequent.
P. elegans	Not rare.
Gaudryina pupoides	Not rare.
Verneuilina propinqua	Rather rare.
Truncatulina lobatula	A few.
Uvigerina asperula	Rare.
Haplophragmium canariense	Rather rare.
H. globigeriniforme	Rather rare.
Nodosaria mucronata	Rare.
Biloculina depressa	Rare.

Some other species and genera appear to be present, as well as occasional diatoms and sponge spicules. The stones appeared to be generally colored with a blackish hue which suggested manganese; but the only reaction observable was that of iron.

The presence of the stones, some of them quite large, some of them water-worn, and one at least polished on one side, intermingled with the ooze, seems to suggest that they must have been dropped into the deposit in recent time. The only manner in which this could occur is by their dropping from masses of floating ice in the process of dissolution. Have we here *debris* imprisoned in the glaciers of Iceland, Greenland, or Labrador, swept around the coast into the margin of the Gulf Stream which helps to whirl a great North Atlantic eddy, and at the same time rapidly dissolves the floating ice from distant coasts, and strews the oozy bottom of the ocean with rock and gravel and clays from many lands?

Both the changing temperature and changing current noted by Captain Trott would seems to suggest that the steamer was at the time near the contact of the Gulf Stream with this North-West Atlantic eddy. If there is such an eddy, we can easily see that it is building up a vast area of soil on the ocean bottom, which is being transported from the glaciated highlands and coasts of the Arctic regions already referred to. The process

may be an illustration of the manner in which some of the fertile fields of our present continents have to some extent been built up.

It is hoped that a large series of such dredgings from exactly noted points in the Atlantic may be obtained for examination. An extensive series of such dredgings might throw much light on the ocean currents and some geological problems, as well as extend our knowledge of the distribution of zoölogical forms on the floor of the ocean.

VII.—Notes on the Geology and Botany of Digby Neck. By Prof. L. W. Bailey, Ph. D., F. R. S. C., *University of New Brunswick, Fredericton, N. B.*

(Read 10th December, 1894.)

Of the more readily accessible portions of Nova Scotia there is probably none less frequently visited, or of which less is known by ordinary travellers, than the peninsula commonly known as Digby Neck. Thus, while hundreds or thousands are, in the course of every summer, whirled along the rails from Yarmouth to Digby, and *vice versa,* or are forced into expressions of admiration as they steam through the wonderful passage of Digby Gut, few ever think it worth while to visit and study the long, curious neck of land whose eastern end forms one of the pillars of that famous gateway, and which, stretching thence to the westward as a narrow and yet almost mountainous ridge, separates the waters of St. Mary's Bay from those of the Bay of Fundy. Even professional naturalists and geologists, usually upon the alert for whatever is new or instructive in the world of nature, would seem in but few instances to have visited Digby Neck, except that portion immediately adjacent to the town of Digby, and observations upon its structure, physical features, mineral contents or floral characteristics, are alike few. And yet it may safely be said that, with the exception of Blomidon, no area of equal extent is to be found in Nova Scotia, and probably not in eastern America, which presents such peculiar features of scenery, geological structure, plant distribution, or mineral associations, as are here met with.

It has hence been thought that the following notes, taken during a sojourn of several weeks upon the Neck, in connection with the work of the geological survey, may be of interest to the members of the Institute, and possibly encourage others to the task of its further exploration.

PHYSICAL FEATURES.

Under the designation of "Digby Neck" will be included, for the purposes of this paper, not only the long narrow ridge properly so called, together with the isthmus by which this is connected with the mainland of Nova Scotia, but also what is clearly but a former extension of this ridge through Long and Briar Islands.

As thus regarded, the area naturally becomes divided physically, as it is also geologically, into two portions, of which the one, comprising the isthmus referred to, is comparatively low, while the other, more by the abruptness of the contrast than by the possession of any considerable altitude, may almost be termed mountainous. This latter is indeed the extension, westward of Digby Gut, of what, eastward of the latter, is commonly known as the North Mountain range.

The total length of this belt of high land, from the Gut to the extremity of Briar Island, is 44 miles; and for much of the distance the breadth varies but little from a mile and three quarters. There are, however, places, as at Sandy Cove, where indentations on opposite sides of the peninsula considerably reduce the actual distance from water to water, while at Petite Passage, and again at Grand Passage, transverse gorges, excavated completely through the peninsula and of great depth, give free movement to those waters as well as to navigation, from side to side. On the other hand, the breadth of the isthmus connecting the mountains with the mainland is, between the one and the other, only about three miles, while between Annapolis Basin and the head of St. Mary's Bay it is about five miles. Near the town of Digby the connecting isthmus includes some rather high and no very low land, but the elevation declines both in the direction of the foot of the higher hills and again towards the head of St. Mary's Bay, where, upon the ebb of the tide, the low shores are prolonged outward into extensive mud-flats.

The maximum elevation of the hilly range is about 350 feet. It would be very incorrect, however, to regard this as a simple ridge extending through the peninsula and sloping from a

central axis to either shore. On the contrary, a series of contour lines would show that while the range is one in its relations to the lowlands, it is itself made up of many subordinate ridges, not quite parallel to the length of the peninsula itself, and so arranged as to form a series of obliquely overlapping lines. The course of the transverse valleys thus formed is usually not far from north and south, and the descent to these, as at Sandy Cove, is usually quite abrupt, while at the Petite Passage, which strikingly illustrates the feature alluded to, the shores on either side stand as well nigh precipitous bluffs overlooking the alternate rush of the tides through that wonderful channel. An admirable opportunity for the study of the orographic features of the peninsula is afforded by a high and conspicuous peak, which, with a nearly vertical face of over one hundred feet, overlooks the picturesque settlement of Sandy Cove. In the almost unobstructed view which may thence be obtained, and of which a part only is shown in the accompanying photograph, Plate IV, not only does the observer marvel at the wonderful beauty and singular characteristics of the immediate foreground, but, for miles to the westward, sees ridge after ridge presenting to the sky an outline which is conspicuously serrated, suggestive of what is actually the case, the existence of table upon table of rocky masses, resting one upon another, each abrupt upon the one side and upon the other sloping gently backward, only to meet and to be capped by other masses similarly inclined. This feature is more marked west of Sandy Cove than to the eastward, and through much of the peninsula in that direction this may be regarded as a sort of trough, formed by and parallel with these bounding ridges. In this trough, through which runs the stage road to Tiverton and Westport, are contained almost all the cultivable lands of the peninsula, and in places long narrow shallow lakes, with connecting streams and meadows.

The peninsula of Digby Neck is thus, as regards its physical features, a district of bold contrasts, including long and prominent ridges, separated in some places by broad and open valleys,

in others by narrow troughs, while across both, at intervals, stretch transverse depressions, always relatively deep, and in some instances sinking far below tide level. In these latter cases, especially at Sandy Cove and in the Petite Passage, the whole structure of the peninsula is admirably exposed, and in the craggy bluffs which border them is determined scenery which in many respects may well be compared with much of that in the vicinity of the Giant's Causeway, in Ireland. So high, indeed, and so steep is much of the shore, particularly upon the southern side, that a safe descent to the beach, if beach there be, is often hard to find and in places quite impossible.

As would naturally be inferred from such diverse physical features, the depth and character of the soil over the peninsula exhibit similar diversity. Thus, on the lowlands of the isthmus, between Annapolis Basin and St. Mary's Bay, where the underlying rocks are sandstones, the soils derived therefrom are naturally also sandy, though, like the corresponding soils of Annapolis Basin, often quite productive. Nearing the hills to the north of this tract, on the other hand, the land rapidly becomes stony, through the distribution of drift, while the hill-slopes themselves are thickly covered with scattered blocks of all sizes. Again on the tops of the hills the soil-covering is usually very scanty and often wholly wanting, but between these, and especially on the transverse valleys, the soils are both deeper and richer, giving support to numerous prosperous farms. The proportion of poor to good land increases progressively to the westward, and in Long and Briar Islands bare ridges of rock are separated only by bogs and swamps.

GEOLOGICAL FEATURES.

The general geological structure of Digby Neck has long been known, and has been made the subject of description by several writers, the most prominent being Sir William Dawson.

As in the region bordering the Annapolis Valley, of which that under consideration is the direct extension, there are in Digby Neck and its vicinity two groups of rocks, the one sedimentary, consisting chiefly of arenaceous beds, of a bright red

colour, and the other volcanic, embracing a variety of doleritic, trachytic, and amygdaloidal rocks disposed in successive sheets as the evident result of repeated lava flows. It has been usual to regard both of these groups as being of New Red sandstone or Jura Trias age. But at present there is, in this region, absolutely no proof that such is their true position, while observations made elsewhere, in rocks of similar character and associations, at least make the reference somewhat doubtful.

By far the best opportunity for the study of the sandstones is afforded by the shore section closely adjacent to the so-called "sea wall," about six miles from Digby, in the settlement of Rossway. At this point is exposed a series of bluffs which, both by their height and colour, form a striking feature in the landscape. The section is nearly half a mile in length, gradually rising with the dip of the strata from the water level at the northern end to quite one hundred feet at the southern. This height above the sea level is not very different from that seen on the road from the town of Digby to Digby Light, and would indicate that the depression in which these sandstones were deposited, and which must at one time have connected the waters of Annapolis Basin and St. Mary's Bay, must have had at least a corresponding depth below its present level.

In character the sandstones are not unlike those seen at various points in the Annapolis valley, but they lack, as far as observed, the gypsiferous aspect which is so marked a feature in the sandstones which underlie the traps of Blomidon. The prevailing colour is a brick-red, of light and dark shades. At intervals it is interstratified with light green bands varying in width from half an inch to 5 or 6 inches. The green bands especially characterize the lower beds, and these are also distinctly more arenaceous than the beds above. On one of the reefs laid bare by the tide was observed what appeared to be a tree-trunk several feet in length, together with some obscure branching markings, which resembled tracks, but both were obscure, and nothing else of this nature could be found.

The traps, which form by far the largest and most conspicuous element in the structure of Digby Neck, have been described as varied, but the diversity which is seen is due rather to mere variations of colour and texture than to any essential difference of composition. And these variations seem to recur without any definite order, the colour even within a few yards often shading off from grey, the prevailing tint, to green or purplish, while both in the coastal cliffs and in the interior, compact or columnar trap is associated very irregularly with beds which are scoriaceous or amygdaloidal. A good opportunity for the study of these rocks is to be had at Gulliver's Cove, to the north of the sandstone section described above, here forming cliffs in some places 100 feet high. They exhibit layers dipping at a slight angle towards the Bay of Fundy, and are intersected by vertical veins from mere streaks to 4 or 5 inches in width. These consist of various silicious minerals, while those occupying the horizontal fissures appear to be chiefly zeolitic. The vertical veins have a strike about NNE. (magnetic).

Other good exhibitions, especially of the columnar structure, may be seen about Digby Light and Broad Cove; but none are so remarkable as those afforded by the depressions of Sandy Cove and the Petite Passage. This latter truly wonderful gap, of which the northern entrance is shown in Plate VI, through which flows alternately a tidal current nearly 100 feet deep, and with a velocity at times of not less than 8 knots, is upon its western side, above the little fishing village of Tiverton, bordered and overlooked by beetling cliffs, of which the individual columns are most complete, and so carved by the sea as to exhibit in places all the aspects of human architecture. The boldness of the scenery is here further enhanced by the occurrence of numerous large blocks of trap, often 20 or 30 feet in diameter, and of grotesque shapes, which are perched, sentinel-like, upon the very edge of the bluffs, more than 100 feet above the water. These, if not "boulders of decomposition," must have been derived from the trappean ridges which, though now invisible through submergence, are known to lie along the Bay of Fundy trough, outside of but parallel to the present coast.

Plate V, accompanying this paper, represents the basaltic structure as seen at Israel Cove, near the southern end of Petite Passage.

Some fine basaltic scenery, of which a sketch is given in "Acadian Geology," is also to be seen on Briar Island, near Westport, but in general the land here is lower and the features less bold than about the Petite Passage.

That so prominent a ridge as that of Digby Neck should have been greatly affected by the conditions incidental to the glacial period, would naturally be expected. These are, however, shown rather in the evidences of enormous denudation than in the production of new deposits. Portions of the ridge are, it is true, somewhat deeply buried in boulder clay; and boulders (including in a few instances granitic and felsitic blocks which must have come from the other side of the Bay of Fundy) are scattered over all parts of its surface; but the occurrence in great profusion of the characteristic rocks of the peninsula along the southern side of St. Mary's Bay, and, though less abundantly, over Yarmouth and Shelburne Counties, even to the Atlantic seaboard, gives forcible illustration of the extent to which the substance of the peninsula has been removed.

The fact also that the transverse valleys of Sandy Cove, Petite Passage and Grand Passage, as well as others less conspicuous, are oblique to the peninsula and almost exactly parallel to each other, while their course corresponds with that of the glacial striation of the district, goes far to favor the view that they owe their origin, partly if not wholly, as has been suggested in the case of Digby Gut, to the excavating action of glacial streams. The occurrence of striations on the surface of the basaltic columns in Israel Cove, and within a few feet of the surface of the water, gives further probability to this view.

MINERALS.

The minerals of Digby Neck are the same as those found in other parts of the North Mountain Range, but are less abundant and less varied than in the section of the latter which lies east of Digby Gut.

Iron ores are both the most abundant and most interesting of these minerals. They occupy veins traversing the trappean rock, and with a tendency, apparently, to run in north and south directions. They occur at many points, the most prominent being along the road from Digby to Digby Light, Nicholl's mine in Rossway, Johnson's mine in Waterford, and Morehouse's mine on the St. Mary's Bay shore near Sandy Cove. At several of these points attempts have been made to remove the ore, and considerable money has been spent, but the small size of the veins and the cost of removal have in all instances prevented them from being remunerative. The ore is sometimes massive, but more generally crystalline, being partly magnetite and partly hematite. Fine crystals of *martite* or octahedral hematite, probably a pseudomorph of magnetite, are especially abundant at Johnson's mine and near Sandy Cove. The mining never proceeded beyond the digging of shallow trenches in the side of the hills, and these are now largely filled with rubbish; but it is among the latter that the most interesting specimens, both of the iron ore and of the associated minerals, are to be had.

Among these associated minerals *quartz* is by far the most abundant, rock crystal being especially common and of great variety and beauty. *Amethysts* are less common, and are now hard to obtain, but very beautiful specimens were disclosed during the opening of the trenches, and are occasionally met with in boulders on the hillsides, or upon the beaches. With these varieties of quartz, and others such as agate, chalcedony and jasper, are often found one or more of the *zeolites*, and many specimens have their beauty much enhanced by the curious way in which the iron ore, rock crystal or amethyst, the zeolitic minerals, and, it may be, white or yellow calcite, are commingled or disposed in alternating layers.

It is of little use to name definite localities for these minerals, other than the mines alluded to above, for the finding of specimens is largely a matter of chance and of diligent search. It may, however, be mentioned that the rocks near the light house in Tiverton (Petite Passage) are especially noticeable for the

large number and varied coloration of the chalcedonic and agate veins which traverse them. These are also found quite abundantly through most of the rocks which border the Bay of Fundy side of the peninsula, and among the blocks with which, in places, this shore is strewn. Among the zeolites some fine specimens, varying in colour from pure white to grey, flesh or cream-colour, red and yellow, as well as of unusual form, were obtained at Johnson's mine in Waterford, where also were observed geodes or amygdules of amethyst and chabazite enclosed in jasper of red and yellow tints. At Murphy's Cove, upon the north shore, about eight miles from Digby, was observed quite a large vein of *Thompsonite.* This has yielded some beautiful groups of crystals, but it is somewhat difficult of access, and has been to a large extent softened and decomposed by exposure to the waves. At Mink Cove, on the south shore of the Neck, in addition to a vein of magnetite, is found a small vein of crystalline calcite, carrying some galena. In general metallic ores, other than those of iron, are of rare occurrence Native copper, it is true, occurs not unfrequently, especially on Briar Island, but, as far as known, only in the form of small granules scattered through the trappean rock.

BOTANICAL FEATURES.

If to the physical and structural characteristics of Digby Neck we add those of its relations, in contour and relief, to its surroundings, it will be readily seen that these are of such a character as must exert a marked influence upon the nature and distribution of its native plants.

It has been stated that the width of the peninsula is nowhere, except at its head, more than two miles, and is generally less Every portion of its surface is therefore more or less subject to the influence of the adjacent waters, more particularly as regards the prevalence of fogs. But while these latter not unfrequently enshroud the whole Neck in a dense and cool atmosphere of mist, the height of the ridge is such that its upper portions are quite often bathed in sunshine, even though the shores and adjacent waters may be wholly concealed from view. The fogs

are also more frequent upon the Bay of Fundy side than upon that of St. Mary's Bay, while the former also feels most keenly the effects of cold northerly winds.

The influence of the above causes, combined with others previously noted as resulting from geological structure and depth of soil covering, are in the first place directly seen in the contrast between the northern and southern sides of the peninsula as regards the variety and vigour of the vegetation, and secondly, in a somewhat marked tendency towards an arrangement of the vegetation in zones, parallel to the length of the Neck and its bounding waters. Lastly, the depth and consequently sheltered positions of such transverse valleys as that of Sandy Cove present still other conditions, the influence of which is directly reflected upon the plants there met with.

The limits and distinctive features of these several tracts have not yet been worked out with any precision, if indeed that is possible, but some of their more general characteristics may be briefly stated.

The first of these zones is that which more immediately forms the northern shore. This, although almost everywhere rocky and in places precipitous, is more commonly low, presenting broad, bare ridges of rock, fringed below by a dense matting of *Fucus*, and sheeted above by patches of grass or low-lying shrubs. On wet and rocky cliffs tufts of *Sedum Rhodiola* are not uncommon, associated with species of Saxifrage, and well indicate the sub-arctic or sub-alpine conditions under which their existence is maintained. The effects of such conditions are also well seen in the woods which generally prevail along this shore of the Neck. They contain much fewer broad-leaved plants than occur farther inland, while their dwarfish and in many instances almost prostrate growth, together with the uniform bending of their trunks and branches away from the direction of the prevalent winds, strikingly attest the effect of their struggle with adverse influences.

From the immediate shore the land upon the north side of the Neck rises rapidly, but often in a succession of steps, with

bare ridges of rock, separated by parallel troughs. This tract is generally densely wooded, but very imperfectly drained, and still exhibits a preponderance of fir, spruce, and hemlock, beneath which are found such plants as *Clintonia borealis, Monotropa, Cornus Canadensis, Pyrola, Brunella, Smilacina, &c.*

Reaching the summit of the ridge more favorable conditions begin to prevail, and with them both a more vigorous growth of trees and a greater variety of herbaceous plants. Among the latter I was surprised and pleased to find a species not previously credited, so far as I am aware, to the flora of Nova Scotia, and not known to occur in New Brunswick, the *Gerardia purpurea* —its small but conspicuous flowers being found abundantly and as late as the middle of September, both on the summit and on the southern side of the trappean hills. In places it was associated with the bright little *Anagallis arvensis*, while in the woods near by were noticed such plants as *Linnaea borealis, Aralia racemosa, Circaea Lutetiana, Mitchella repens, Chiogenes hispidula, Chimaphila umbellata, Epigaea repens, Pyrola rotundifolia, Trientalis Americana, Spiranthes, Scutellaria, Galium, &c.* At one point, but at one only in this belt, was noticed *Clematis Virginiana*, twining its conspicuous leaves and fruits over dense clusters of alder.

The next zone is that of the cleared lands bordering on either side the main road which traverses the peninsula throughout its length. Here, in the fields, are found the plants usual in such situations, the ubiquitous Ox-eye-Daisy, two species of Thistle, and a variety of Asters and Solidagoes, while in places are to be seen dense clusters of Elecampane (*Inula Helenium*) and Tanzy (*Tanacetum vulgare*). Along the roadsides and ditches alders abound, associated generally with patches of Meadow Rue (*Thalictrum Cornuti*), Meadow sweet (*Spiraea salicifolia*), *Rubus, Rosa, Ribes, Eupatorium, Antennaria,* and occasionally *Ocnothera biennis.* In portions of this belt, where ponds occur, were noticed such water plants as *Eriocaulon septangulare, Potamogeton natans, Sparganium simplex, &c.* The yellow

Lily (*Nuphar advena*) was also common, but *Nymphaea odorata*, the white Water-lily, was seen at one point only, in the little pond midway between the northern and southern outlets of Sandy Cove, its occurrence here being in keeping with the warm and sheltered position of its habitat.

The southern side of the peninsula, fronting St. Mary's Bay, may perhaps be regarded as forming another zone, but is less well-defined than those previously noted, and marked rather by the more general prevalence of broad-leaved trees and their comparatively vigorous growth, than by the occurrence of any special species.

Finally, over the red sandstone district constituting the isthmus connecting Digby Neck with the mainland, the species found are the same as those of the Annapolis Valley, of which pretty full lists have been elsewhere published. The growth of the Horse-Chestnut is especially noticeable.

Towards the western extremity of the peninsula and upon Long Island, its natural extension, the above zones (excepting the last which is here wholly wanting), tend to blend or to disappear, while the increasing amount of low and boggy ground is accompanied by the corresponding augmentation of ericaceous plants, such as *Vacciniums*, *Ledum*, *Kalmia*, *Cassandra*, *&c.* *Potentilla fruticosa* was also noticed here at several points, forming dense clusters. *P. anserina* was also of common occurrence. Finally, over the surface of peat bogs, especially on Briar Island, were to be found the different species of *Drosera* (*D. rotundifolia* and *D. intermedia*), *Sarracenia purpurea* and the Orchids *Habenaria psycodes* and *H. blephariglottis*. Nowhere have I seen these Orchids so abundant as over the barrens and peat bogs of Digby and Yarmouth Counties.

Appended is given a more complete list of the plants observed on Digby Neck. While by no means embracing all the species which are doubtless represented there, it may be useful as a basis both for comparison and for further exploration.

PLANTS OF DIGBY NECK.

Clematis Virginiana, L.
Nymphaea odorata, Ait.
Nuphar advena, Ait.
Sarracenia purpurea, L.
Drosera intermedia. D. longifolia, L.
Hypericum —— ?
Silene —— ?
Geranium Robertianum, L.
Impatiens fulva, Nutt. I. pallida.
Rhus typhinia. L.
Potentilla anserina, L. P. fruticosa, L.
Rubus Canadensis, L. R. strigosus. R. villosus, Ait.
Rosa Carolina, L.
Spiraea salicifolia, L. S. tomentosa, L.
Trifolium arvense, L. T. Agrarium, L.
Aesculus Hyppocastanum.
Acer Pennsylvanicum, L. A. spicatum, Lam.
Saxifraga —— ?
Sedum Rhodiola, D. C.
Circaea Lutetiana, L.
Epilobium angustifolium, L. E. coloratum, Muhl.
Oenothera biennis, L.
Cornus Canadensis. C. alternata.
Linnaea borealis, Grown.
Viburnum lantanoides.
Galium —— ?
Eupatorium purpureum, L.
Aster nemoralis, Ait., and others.
Solidago —— sp ? S. sempervirens.
Inula Helenium, L.
Achillea millefolium, L.
Leucanthemum vulgare, Lam.
Tanacetum vulgare, L.
Antennaria margaritacea, R. Br. A. plantaginifolia, Hook.

Cirsium arvense, Scop.
Leontodon autumnale, L.
Onapordon acanthium, L.
Lappa officinalis.
Rudbeckea hirta, L.
Maruta cotula, D. C.
Campanula rotundifolia, L.
Vaccinium Canadense, Kalm.
Monotropa uniflora.
Chiogenes hispidula, Tr.
Chimaphila umbellata, Nutt.
Plantago major, L. P. maritima, L.
Trientalis Americana, Pursh.
Anagallis arvensis, L.
Utricularia —— sp ?
Verbascum Thapsus, L.
Gerardia purpurea, L.
Linaria vulgaris, Mill.
Chelone glabra.
Mimulus ringens.
Veronica —— sp ?
Brunella vulgaris, L.
Scutellaria galericulata, L.
Polygonum persicaria, L.
Rumex acetosella.
Fagus ferruginea, Ait.
Corylus rostrata.
Betula.
Alnus incana, Welld.
Salix —— sps ?
Pinus strobus, L.
Abies alba ? Muhr. A. balsamea. A. Canadensis.
Arisaema triphyllum, Tor.
Typha latifolia, L.
Sparganium simplex, Hud.
Habenaria psycodes, Gray.

Spiranthes —— ?
Iris versicolor, L.
Sisyrinchium Bermudianum, L.
Trillium erectum, L. T. erythrocarpum, Michx.
Streptopus roseus. Michx.
Clintonia borealis, Raf.
Smilacina bifolia, Kerr.
Eriocaulon septangulare, Witg.
Eriophorum ———

NOTE.—No attempt was made to identify Carices, Grasses, Equiseta, Ferns, or Mosses.

VIII.—THE FLORA OF NEWFOUNDLAND, LABRADOR AND ST. PIERRE ET MIQUELON: PART II. BY THE REV. ARTHUR C. WAGHORNE, *St. John's, Newfoundland.*

(Read 13th May, 1895.)

Circumstances have unhappily delayed the compilation of these notes. The first paper was read before the Institute on April 10th, 1893, and was published in its Transactions of the 2nd series, Vol. I., beginning at page 359. That dealt with Polypetalæ, as far as Leguminosæ, inclusive. This second paper completes the Polypetalæ and includes a supplementary list of plants belonging to the earlier portion of this division, which have been found by the compiler and others since it was published, or of whose claim to be included therein he has since been assured. The plants in this supplementary list are additions either to the Newfoundland or Labrador flora.

This fuller knowledge of our flora, which yields these supplementary plants, and which renders the whole list more complete and accurate, is derived from various sources, which are chiefly these :—

1. The writer's own discoveries for 1893 and 1894. These mostly concern the Labrador, as the greater part of both these summers were spent on that coast, that of 1893 extending from the Strait of Belle Isle (the southernward point being Bradore), northwards through the Battle Harbour district, as far as Sandwich Bay. Last summer his journeyings were confined to the Strait of Belle Isle. The Newfoundland plants were almost exclusively collected in Notre Dame Bay, on the North-east coast, chiefly about Exploits.

2. Dr. Packard's "The Labrador Coast" contains a list of Labrador plants extending over 22 pages, compiled for the author by Professor Macoun. This list affords a few additions to those plants included in Professor Macoun's "Catalogue of Canadian

Plants," mostly the collections of the Moravian missionaries in Northern Labrador.

3. Dr. Robinson, Professor of Harvard University, with Mr. Schrenk, spent a month or so in Newfoundland last summer. and their researches have added considerably to our knowledge of the flora of this country. Dr. Robinson has generously presented to us a collection of these plants, and this collection affords, of course, valuable aid in the compilation of this list.

4. The Revd. R. Temple, Rural Dean of Notre Dame Bay, kindly handed over to the compiler a few plants collected by him some years ago, which have added a few names to our list. But for the most part Mr. Temple's plants give no data as to whether they were collected at Ferryland, on the South, or at White Bay, on the North-eastern coast.

Dr. D. C. Eaton, of Yale, and Professor J. Fowler, of Queen's University, Kingston, have kindly named most of the collections of 1894, as far as they are included in this paper.

The writer's introduction to the previous paper probably conveys whatever else need be stated by way of preface.

(Ranunculaceæ, &c., to Leguminosæ, Supplementary to Part I.).

I.—RANUNCULACEÆ. *Crowfoot or Buttercup Family.*

3. *Actæa spicata,* Linn. var. *rubra.* Ait. *Lab:* L'anse au Clair and L'anse au Mort. (A. C. W.—Fowler). Low woods. August.

1. *Anemone parviflora,* Michx. Ferryland or White Bay (Revd. R. Temple—Fowler).

7. *Ranunculus abortivus,* Linn. *Lab*: L'anse au Clair and Blanc Sablon. Wet places. (A. C. W.—Fowler and Coville.) July.

12. *R. Flammula,* Linn. Freshwater Road, St. John's (Prof. Holloway, Fletcher). Wet places. July.

Var: *intermedius,* Hook. Quidi Vidi Lake, St. John's (Robinson and Schrenk). Muddy shores. August.

Var: *reptans*, Meyer. New Harbour (A. C. W.); Ferryland or White Bay (Revd. R. Temple—Fowler); St. John's (Miss Southcott); Placentia (Lady Blake); rocky banks of Rennie's River, St. John's (Robinson and Schrenk). July. *Lab*: Forteau and Independent (A. C. W.—Macoun and Fowler). Edges and ponds. August.

8. *R. hederaceus*, Linn., St. John's (Miss Southcott). Road side ditches, shores of Quidi Vidi Lake (Robinson and Schrenk). August.

133. *R. aquatilis*, Linn. var. *trichophyllus*. Chaix. *White Water Crowfoot.* Exploits River, near Badger's Brook (Robinson and Schrenk). August.

134. *R. Macounii*, Britton (R. hispidus, Hook). Placentia. Wet ground. (Robinson and Schrenk). August. [Probably *R. repens*. Var. *hispida*, Torr. and Gray.]

135. Ranunculus— ? Rocky banks of Rennie's River, St. John's (Robinson and Schrenk). August.

III.—NYMPHÆACEÆ. *Water Lily Family.*

27. *Nuphar advena*, Ait. Var. *minus*, Morong. Pond at Whitbourne (Robinson and Schrenk). August.

26*a*. *Nymphœa odorata*, Ait. Var. *minor*, Sims. *Lesser Water Lily.* Whitbourne (Robinson and Schrenk). August.

VII.—CRUCIFERÆ. *Mustard Family.*

48*a*. *Draba incana*, Linn. Var. *arabisans*, Wats. White Bay? (Revd. R. Temple—Fowler). *Lab:* Hopedale (Weiz) [Packard]; L'ansc au Clair (A. C. W.—Fowler). July.

136. *D. aurea* Vahl. *Lab:* Hopedale (Weiz) [Packard].

137. *D. hirta*, Linn. *Lab:* L'anse au Mort (A. C. W.—Fowler). Rocky banks. July.

42. *Cakile Americana*, Nutt. *Lab:* English Point (Forteau) and L'anse au Mort (A. C. W.—Eaton). Sea Beach. September.

40. *Cardamine hirsuta*, Linn. Along Railway track, Whitbourne (Robinson and Schrenk). August. *Lab:* L'anse

au Clair and L'anse au Mort (A. C. W.—Eaton and Fowler) Streams. July and September.

60. *Thlaspi arvense*, Linn. *Lab*: About houses at Capstan Island and Pixware River (A. C. W.—Eaton and Fowler). August.

138. *Nasturtium palustre*, D. C. *Marsh cress.* Cartwright. Wet places about parsonage (A. C. W.—Fowler). September.

139. *N. sylvestre*, R. Br. Banks of Rennie's River, St. John's (Robinson and Schrenk). August.

36. *Barbarea vulgaris*, R. Br. *Lab*: Near Forteau Light House and near Blanc Sablon (A. C. W.—Eaton and Fowler). July and August.

Var: *stricta*, Regel. *Common Winter Cress.* *Lab*: Capstan Island (A. C. W.—Eaton). July.

140. *Cochlearia Anglica*, Linn. *English Scurvy Grass.* *Lab*: Partly Modiste and L'anse au Clair (A. C. W.—Eaton and Fowler). July and August.

141. *Senebiera prunatifida*, D. C. S. John's surface drains, (Robinson and Schrenk). July.

VIII.—VIOLACEÆ. *Violet Family.*

65. *Viola canina*, Linn. *Lab*: A specimen from L'anse au Mort was thus doubtfully named by Dr. Eaton. August.

XIV.—CARYOPHYLLACEÆ. *Pink Family.*

142. *Stellaria graminea*, Linn. S. John's; borders of fields (Robinson and Schrenk). July.

96. *S. longifolia*, Muhl. To the references of occurrences in Newfoundland given in previous paper may now be added, Salmonier River, quarry bottoms. (Robinson and Schrenk). August. *Lab*: L'anse au Clair (A. C. W.—Fowler.) July.

143. *Spergularia rubra*, Presl. S. John's, road-sides (Robinson and Schrenk). August. Ferryland or White Bay (Revd. R. Temple—Fowler).

77. *Cerastium alpinum*, Linn. Var. *glabatum*, Hook. *Lab*: Hopedale (Weiz), Nachvak (R. Bell), [Packard].

Begin

XVII.—GERANIACEÆ. *Geranium Family.*

144. *Geranium Carolinianum*, Linn. *Carolina Cranes-bill.* Sambo (Revd. J. H. Bull, Dewey); Railway ballast, 15 miles north of Placentia Junction (Robinson and Schrenk). July and August.

XX. LEGUMINOSÆ. *Pea Family.*

118. *Astragalus oroboides*, Hornem. A doubtful specimen from Badger's Brook, Exploits, collected by Revd. J. H. Bull. Submitted to Prof. Fowler, July.

145. *Trifolium hybridum*, Linn. *Alsick.* Whitbourne (Robinson and Schrenk). August.

PART II.—POLYPETALÆ *(Continued.)*

(*Rosaceæ, &c.*, to the end of the *Polypetalous* plants.)

XXI. ROSACEÆ. *Rose Family.*

146. *Agrimonia Eupatoria*, Linn. Common Agrimony. (Reeks). Topsail (Cat. IV., 518); Islands in Salmonier River (Robinson and Schrenk). August.

147. *Amelanchier Canadensis*, Torr. and Gray. *June Berry* (*Indian or Wild Pear*). (Reeks). (Cat. I., 148). Flat Bay, West Coast (Bell); west of Random (Cormack), *Cyrus Botryapium*, he calls it); New Harbour, S. John, (Robinson and Schrenk). Woods. June, July.

a. Var: *oligocarpa*, Torr. and Gray. (Cat. I., 149); S. John's (Miss Southcott); New Harbour. June, July. *Lab*: Swamps in Southern Labrador, (Butler). Deep Water Creek and Pack's Harbour (A. C. W.) July, August. *Flora Miq.* Peaty and stony places. Common. July.

b. Var: *Botryapium?* (A specimen from Grand Bank was thus doubtfully named by Prof. Macoun.)

c. Var: *oblongifolia*, Torr. and Gray. New Harbour (A. C. W. [Fowler]). June.

148. *Alchemilla vulgaris*, Linn. *Common Ladies' Mantle.* Twillingate (A. C. W.) August. *Lab*: Abundant on hillsides, Amour (Butler). Battle Harbour, L'anse au Loup and Blanc Sablon (A. C. W.) July, August.

149. *Cratægus coccinea*, Linn. *Scarlet-fruited Thorn.* Several places about Humber River (Bell). Bay Despair in Hermitage Bay (Mrs. Gallop [Macoun]).

150. *C. oxyacantha*, Linn. *English Hawthorn.* Hedges in S. John's (A. C. W.)

151. *Dryas octopetala*, Linn., var. *integrifolia*, Cham. & Schlecht. *Lab*: Hills about Amour (Butler) and at Battle Harbour (A. C. W.) Nackvak and Cape Chidley (Cat. III, 515). Hopedale (Weiz) [Packard]. July.

152. *Fragaria Virginiana*, Duchesne. *Wild Strawberry.* (Reeks). S. John's, New Harbour, Topsail, Exploits (A. C. W.) May, June. *Lab*: Sparingly, hillsides at Amour and Southern Labrador (Butler). Various places in the Straits of Belle Isle (A. C. W.) [Fowler]. July, August.

153. *F. vesca*, Linn. *Wood strawberry.* New Harbour; doubtful specimen (A. C. W.—Fowler). (Reeks). Banks of Manuel's River, Topsail (Robinson and Schrenk). June and July. *Flora Miq.* Common; stony and sandy places; fruit excellent; ripe about the end of July; flowers early in July.

154. *Geum macrophyllum*, Willd. *Straight yellow-leaved Avens.* (*Blood root* in White Bay; *Jack root* in Trinity Bay.) (Reeks). Western Cove (White Bay); Flat Bay Brook on West Coast (Bell). July, Oct. *Lab*: Battle Harbour and near Blanc Sablon (A. C. W.) July, August.

155. *G. rivale*, Linn. *Purple or Water Avens (Chocolate root).* (Reeks). Flat Bay Brook (Bell); (Cat. I., 133). West of Random (Cormack), S. John's (Lady Blake). New Harbour and neighbourhood, Harbour Breton (Fortune Bay), (A. C. W.) Moist woods near Salmonier River (Robinson and Schrenk). July, August. *Lab*: Brooksides, Southern Labrador (Butler), springy places all along coast (Cat. III., 515). July, August.

156. *G. strictum*, Ait. *Flora Miq.* Marshy places; rare. July.

157. *G. triflorum*, Pursh. (Reeks). *Lab*: (Cat. I., 134). Dry, rocky ground. (Judge Morrison) [Packard].

158. *Poterium Canadense*, Benth. and Hook. *Canadian or Salad Burnet, or Indian Tobacco.*) (Reeks). Great Cod

Roy River (Bell); S. John's (Miss Southcott); rather common about Trinity and Fortune Bays (A. C. W.) (Cat. I., 143). August and September. *Lab*: Abundant on hillsides on South Coast (Butler). August. *Flora Miq.*; very common. August. Furnishes good forage for ruminants.

159. *Prunus pumila*, Linn. *Sand or Dwarf Cherry*, [Bonycastle].

160. *P. Pennsylvanica*, Linn. *Bird or Pigeon Cherry.* (Cat. I., 125); Random (Cormack); Flat Bay Brook and Deer Lake (Bell); Bonne Bay, South (Reeks); New Harbour (A. C. W. [Fowler]); Banks of Salmonier River (Robinson and Schrenk). Woods. June, August. *Flora Miq.*; common. July. *Lab*: Caribou Island (S. R. Butler).

161. *P. serotina*, Ehrt. *Black cherry. Flora Miq;* woods of Mirande, Sylvain, Langlade wood; rare. July.

162. *P. Virginiana*, Linn. *Choke cherry (Chuckley plum or Mazzard)* Random (Cormack); Deer Lake (Bell); S. John's (Miss Southcott); Exploits River (Austin); Harbour Breton (A. C. W.) Along Salmonier River (Robinson and Schrenk). Woods. July and August.

163. *Potentilla argentea*, Linn. *Silvery Cinquefoil* (Reeks).

164. *P. anserina*, Linn. *Silverweed.* Common in many places by sea coast. June, July. *Lab*: Flats near the shore (Butler); Battle Harbour and other places (A. C. W.) July, August. *Flora Miq.*, sandy places near houses; common. June.

165. *P. emarginata*, Pursh. *Lab*: Cape Chidley (Cat. I., 100; III., 518). (Packard).

166. *P. fruticosa*, Linn. *Shrubby Cinquefoil.* Very common on rocky margins of rivers and lakes from Labrador and Newfoundland to the Pacific, and northward to the Arctic Sea (Cat. I., 141); not uncommon in Trinity and Fortune Bays (A. C. W.); Flat Bay Brook (Bell); marshy ground at Manuel's, Topsail (Robinson and Schrenk). August. *Lab*: Forteau (A. C. W.) July. *Flora Miq.*, damp places, edges of water-courses. July, August.

167. *P. maculata*, Poir. *Lab*: Nain and Nachvak, Cape Chidley (Cat. I., 140; III., 518); Long Point (A. C. W.); Hills about Amour (Butler); Hopedale (Weiz.) [Packard]. July, August.

168. *P. nemoralis*, Nestler. White Bay or Ferryland (Revd. R. Temple—Fowler). *Lab:* (Cat. I., 142). L'anse au Mort (A. C. W.—Fowler). July, August.

169. *P. nivea*, Linn. *Lab:* (Cat. I., 139); Hopedale (Weiz). [Packard].

170. *P. Norvegica*, Linn. (Reeks). S. John's (Prof. Holloway [Fowler]); Flat Bay Brook (Bell); Trinity and Fortune Bays (A. C. W.); along railway track, Whitbourne (Robinson and Schrenk). August. *Lab:* all along coast (Butler); (Cat. I., 516). "Quite smooth and distinct from ordinary form, very likely the P. Labradorica of Lehmann"). Battle Harbour (Bull [Macoun]).

170*a*. Var: *hirsuta*, Torr. and Gray. Trinity Bay (Cormack, P. hirsuta).

171. *P. Pennsylvanica*, Linn. White Bay (Revd. J. S. Andrewes [Macoun]).

172. *P. tridentata*, Solander. *Mountain or Three-Toothed Cinquefoil* (Cat. I., 141). Appear to be common everywhere in exposed places (A. C. W.); common in the interior (Cormack). In August. *Lab:* (Cat. I., 41). Many places on the Labrador (A. C. W.) July. *Flora Miq.*, very common in stony and peaty places. In August.

173. *P. palustris*, Scop. *Marsh five-finger*. (Reeks); New Harbour and Arnold's Cove (Placentia Bay); (A. C. W.) Wet places and bogs. July. *Lab:* (Cat. I., 140). Not uncommon along coast of Southern Labrador. July, September. *Flora Miq.* August.

174. *Pyrus Americana*, D. C. *American Mountain Ash* (*Dog-berry* or *Pig-berry*). Common in most places in woods. June, July. *Lab:* in gulches and on hills (Butler).

174*a*. Var: *microcarpa*, T. & G. (*Cat-berry*). S. John's (Miss Southcott); New Harbour. *Lab:* not rare over Labrador coast (Cat. III., 522); Fox Harbour (A. C. W.); Hopedale (Weiz). [Packard]. August.

175. *P. sambucifolia*, Cham. and Schlecht. Whitbourne (Robinson and Schrenk). Woods. August.

176. *P. arbutifolia*, Linn. *Choke-berry* (*Winter, Low or Indian Pear*). S. John's (Miss Southcott); West of Random (Cormack); near Cairn Mountain, Flat Bay (Bell). Common near Brigus (Cat. III., 521) and many other places. Bogs and wet places. May, July.

176*a*. Var: *melanocarpa*, Hook. New Harbour. *Lab:* (Flora Miq.) *Flora Miq.*, commonly called Wild Pear. Common. July.

177. *P. malus*, Linn. Wild Apple. *Flora Miq.* Met once between Cape de la Demoiselle and Bellevaux Wood. Rare even at Longlade, and doubtless introduced; creeping, and has produced apples as large as a pigeon's egg. Flowers in July.

178. *Rosa blanda*, Ait. *Early Wild Rose.* On rocks and rocky shores of rivers and lakes (Cat. III., 518); Harbour Breton (A. C. W.)

179. *R. Carolina*, Linn. *Swamp Rose.* (Reeks). About New Harbour (A. C. W.)

180. *R. lucida*, Ehrt. (Reeks); (Cat. I., 143; III., 519); New Harbour and Harbour Breton (A. C. W.)

181. *R. nitida*, Willd. (Cat. I., 145; III., 521). Topsail (A. C. W.); S. John's (Miss Southcott and Robinson and Schrenk); West of Random (Cormack); Harbour Breton. *Flora Miq.*, dry or slightly wet places; common. August.

182. *R. Sayii*, Schwein. Harbour Grace (Cat. I., 144: IV., 520.)

183. *R. pimpinellifolia*, Linn. *Flora Miq.* ("mentioned by Southier, and not found by us; if this case exists in Miquelon, it has been introduced there.")

184. *Rubus arcticus*, Linn. *Arctic Raspberry or Bramble.* (Ground Raspberry and Plumboy, Labrador) (Cat. I., 129); (Reeks). *Lab:* (Cat. I., 129); level grassy places (Butler) in Southern Labrador; not uncommon in the Straits of Belle Isle. July, August. *Flora Miq.* July.

184*a*. Var: *grandiflorus*, Ledeb. *Lab:* From Labrador to the woods and swamps of the Rocky Mountains, Lat. 52°-56°, (Drummond), (Cat. I., 129). Nain and Nachvak (Cat. III., 514). Indian Harbour, Holton (A. C. W.) July, August.

185. *R. Canadensis*, Linn. (Cat. I., 131): (Reeks); S. John's (Miss Southcott); New Harbour (A. C. W.) Open grounds at Whitbourne (Robinson and Schrenk). *Flora Miq.* July, August.

186. *R. Chamœmorus*, Linn. *Cloudberry. (Bake apple).* Very common in most parts of Newfoundland and the Labrador; in peat bogs and wet places (Cat. I., 128; III., 514). May, June. *Flora Miq.* Very abundant in the peaty plains of Miquelon. Flowers in June; fruit ripens in August.

187. *R. hispidus*, Linn. *Swamp Blackberry.* (Reeks).

188. *R. occidentalis*, Linn. *Black Raspberry.* West of Random (Cormack).

189. *R. strigosus*, Michx. *Red Raspberry.* Very common in most parts of the country. July. *Lab:* (Cat. I., 130). In inland gulches (Butler); frequent in many places from the Straits to Hamilton Inlet. *Flora Miq.*

190. *R triflorus*, Richards. *Dewberry, Plumboy.* Common in many places in woods and wet places. May, June. *Lab:* (Cat. I., 130); hillsides in S. Labrador (Butler); Capstan Island, and several places in the Strait and more northern (A. C. W.) July, August. *Flora Miq.* Damp and stony places; common. July.

191. *R. villosus*, Ait. *Thimbleberry or Bramble. (English Blackberry).* Several places in Trinity and Fortune Bays (A. C. W.); Cairn Mountain, Flat Bay (Bell); Brigus and Topsail (Cat. III., 514). July. I have never or scarcely ever seen the fruit fully ripe, but I am assured that the berries ripen fully, and are sold in small quantities about Burin.

a. Var: *frondosus*, Torrey. (Cat. I., 131).

b. Var: *humifusus*, Torr. and Gray. S. John's (Miss Southcott); New Harbour and Harbour Breton (A. C. W.) The specimen from New Harbour is reported by Prof. Macoun as near var. *humifusus*.

192. *R. Idæus*, Linn. *Flora Miq.*; marshy, peaty and stony place; common. August.

192½. *Sibbaldia procumbens*, Linn. *Lab:* Cape Chidley (Cat. I., 138; III., 516). Labrador (McGill College Herb.); Hopedale (Weiz) [Packard].

193. *Spiræa salicifolia*, Linn. *Common Meadow Sweet. (Deadman's flowers).* (Reeks); S. John's (Miss Southcott); fairly common in Trinity Bay and elsewhere (A. C. W.); low, damp places, generally near ponds and margins of streams from Newfoundland to base of Rocky Mountains (Cat. I., 126). *Flora Miq.*; common. August

194. *S. tomentosa*, Linn. *Hardhack, Steeplebush.* (Reeks).

XXII. SAXIFRAGACEÆ. *Saxifrage Family.*

195. *Mitella diphylla*, Linn. *Mitre-wort or Bishop's cap.* Cow Head? (A more common species than the next. Reeks.)

196. *Mitella nuda*, Linn. *Dwarf or Naked-stalked Mitella*, (Cat. I., 157). Several places about New Harbour (A. C. W.—Macoun); Flat Bay (R. Bell); common at Cow Head (Reeks); Englee (A. C. W.) July, August. Woods. *Lab:* (Cat. I., 157). Hillsides, Forteau (S. R. Butler), and several other places in Southern Labrador (A. C. W.); cool, damp places (Hooker). [Packard]. July, August.

197. *Parnassia parviflora*, D. C. (Cat. I., 159). *Lab:* (Cat. I., 159). L'anse au Mort, Holton, Forteau and Long Point (A. C. W.—Macoun and Fowler). July, August. Wet places.

198. *P. palustris*, Linn. *Common Grass of Parnassus.* Doubtful specimen from Chance Cove (A. C. W.—Macoun). *Lab:* (Cat. I., 159). Hopedale (Weiz), (Hooker) [Packard]. Fox Harbour and Battle Harbour (A. C. W.) July. Wet rocky places.

199. *P. Kotzebuei*, Cham. and Schlecht. *Lab:* (McGill College Herb.—Cat. I., 160). Hopedale (Weiz), [Packard].

200. *Ribes prostratum*, L'Her. *Fetid or Mountain Currant.* (Cat. I., 162); near Cairn Mount, Flat Bay (R. Bell); West of Random (Cormack); S. John's (Miss Southcott); New Harbour (A. C. W.) May and June. *Lab:* (Cat. I., 162). Common in

ravines of Southern Labrador (S. R. Butler); S. Michæls and L'anse au Clair (A. C. W.—Macoun and Fowler), July, August. *Flora Miq.*; rare. July.

201. *R. rubrum*, Linn. *Red Currant.* (Reeks); Great Cod Roy River (R. Bell). July.

202. *R. lacustre*, Poir. *Swamp Gooseberry* (Cat. I., 162); Great Cod Roy River (R. Bell); (Reeks), Englee, in White Bay (A. C. W.) July. *Lab:* (Cat. I., 162); common in ravines in Southern Labrador (S. R. Butler), L'anse au Clair and L'anse au Mort (A. C. W.—Fowler). July, August. Wet woods.

203. *R. oxyacanthoides*, Linn. *Smooth Wild Gooseberry* (Cat. I., 161); S. John's (Miss Southcott); Harbour Breton and Belleoram (A. C. W.) *Lab:* L'anse au Clair (A. C. W.—Fowler). July.

204. *Saxifraga Aizoon*, Jacq. Ferryland or White Bay (Revd. R. Temple—Fowler). *Lab:* (Cat. I., 150), (Judge Morrison); Hopedale (Weiz) [Packard].

205. *S. aizoides*, Linn. *Yellow Mountain Saxifrage.* Port a Port, S. George's Bay (R. Bell), (Cat. I., 155). White Bay? (Revd. R. Temple—Fowler). *Lab:* on rocks, Forteau (S. R. Butler); Nachvak (R. Bell) [Cat. III., 525]; Hopedale (Weiz) [Packard]; L'anse au Mort (A. C. W.—Fowler). Rocky banks. August.

206. *S. cæspitosa*, Linn. *Tufted Alpine Saxifrage.* (McGill Coll. Herb.) [Cat. I., 150]. Englee (A. C. W.) *Lab:* Forteau Bay (S. R. Butler) Nachvak (Cat. I., 150; III., 523). Battle Harbour (A. C. W.)

Var: *Grœnlandica*, Wahl. *Lab:* Hopedale (Weiz). [Packard; perhaps all the last references belong here.]

207. *S. cernua*, Linn. *Drooping Bulbous Saxifrage.* (Pursh. Cat. I., 151). *Lab:* (Pursh. Cat. I., 151; III., 524); Cape Chidley (R. Bell); Hopedale (Weiz), [Packard].

208. *S. nivalis*, Linn. *Clustered Alpine Saxifrage.* *Lab:* (Pursh), Nachvak. Cape Chidley (R. Bell. Cat. I., 152; III., 524); Hopedale (Weiz). Caribou Island (S. R. Butler—Packard); Bolster Rocks (Revd. J. H. Bull—Macoun). August.

209. *S. oppositifolia*, Linn. *Purple Mountain Saxifrage.* (Cat. I., 149; in dense clusters in exposed places at Goblin Head, Hermitage Bay (Dr. Fitzgerald—Macoun). *Lab:* Cape Chudleigh (Cat. I., 109; III., 523); Battle Harbour (Revd J. H. Bull—Fletcher); rocks, Amour (S. R. Butler); Hopedale (Weiz), [Packard]; L'anse au Mort (A. C. W.) August.

210. *Saxifraga rivularis*, Linn. *Alpine Brook Saxifrage.* S. Anthony (A. C. W.) August. *Lab:* (McGill Coll. Herb.), Nachvak, Cape Chudleigh (R. Bell. Cat. I., 151; III., 523); Hopedale (Weiz) [Packard]; Battle Harbour and Holton (A. C. W.) July.

211. *S. stellaris*, Linn. *Starry Saxifrage. Lab:* (Morrison. Cat. I., 152).

212. *S. tricuspidata*, Retz. *Lab:* (McGill Coll. Herb.) Nachvak (R. Bell), (Cat. I., 154; II., 525).

213. *S. hieracifolia*, Waldst. and Kit. *Lab:* Hopedale (Weiz.) [Packard].

XXIII. CRASSULACEÆ. *Orpine Family.*

214. *Penthorum sedoides*, Linn. *Ditch Stone-crop.* (Reeks).

215. *Sedum Rhodiola*, D. C. *Rose root (Midsummer men,* on the Labrador, also, *Houseleek* and *Scurvy Grass).* (Cat. I., 165), Common in many parts of Newfoundland, especially on sea-cliffs. *Lab:* (Cat. I., 165). Frequent along the coast (A. C. W.) [Packard]. *Flora Miq.* Rare. July. Cleft of rocks.

216. *S. Telephium*, Linn. *Live for Ever.* S. John's Hospital grounds (A. C. W.—McKay). August. *Lab:* L'anse au Mort (A. C. W.—Fowler). Sea-beech. August.

217. *S. acre*, Linn. *Mountain Moss.* S. John's (Miss Cowling). Specimen named by Mr. Fletcher doubtfully.

XXIV. DROSERACEÆ. *Sundew Family.*

218. *Drosera rotundifolia*, Linn. *Round-leaved Sundew (Flycatcher).* "A common inhabitant of peat bogs and marshes from Newfoundland and Labrador to the Pacific and north to, and beyond, the Arctic Circle." (Cat. I., 165. *Flora Miq.*; in all marsh places of the Island. July, August. [Called *Musk rat flower* in White Bay).

219. *D. Anglica*, Hudson. *Great Sundew.* (Watson; Cat. I., 166).

220. *D. intermedia*, Drev. and Hayne. Var. *Americana*, D. C. *Long-leaved Sundew.* New Harbour (A. C. W.); sphagnum swamp, Manuel's (Robinson and Schrenk); Ferryland or White Bay (Revd. R. Temple—Fowler). August. *Flora Miq.* Less common than the first named. July, August.

XXV. HALORAGEÆ. *Water Milfoil Family.*

221. *Myriophyllum spicatum*, Linn. *Spiked Water Milfoil.* In abundance about Deer Lake, on West Coast (R. Bell). (Cat. I., 166).

222. *M. alternifolium*, D. C. Whitbourne. Immersed in shallow water of ponds (Robinson and Schrenk). August.

223. *M. verticillatum*, Linn. *Whorled Water Milfoil* (Reeks). *Flora Miq.* This and the first in stagnant water of the plain and Market Place Point of Miquelon. Common. July.

224. *M. tenellum*, Bigl. Water places (Cat. I., 167); (Reeks); New Harbour Brook (A. C. W.); shallow water, Quidi Vidi Lake, S. John's (Robinson and Schrenk). August.

225. *Hippuris vulgaris*, Linn. *Common Mare's Tail.* Pools of water and margins of lakes in Newfoundland and Labrador (Cat. I., 167); near Bonne Bay, rare (Reeks); muddy banks Exploits River, near the mouth of Badger's Brook (Robinson and Schrenk); ponds, Tickle Harbour and Harbour Deep (A. C. W.) August. *Lab:* Cape Chudleigh (R. Bell. Cat. I., 167; III., 529); Hopedale (Weiz) (Packard]; Fox Harbour (A. C. W.) *Flora Miq.* Damp places; common. July.

226. *H. maritima*, Hellenius. *Lab:* (Morrison. Cat. I., 168).

227. *Callitriche verna*, Linn. *Spring Starwort.* (Reeks). *Lab:* Capstan Island, Long Point and Battle Harbour (A. C. W. Macoun and Fowler); ponds.

228. *C. autumnalis*, Linn. *Autumnal Starwort.* Green's Harbour (A. C. W.) August.

229. *C. heterophylla*, Pursh. Whitbourne; borders of ponds (Robinson and Schrenk.) August.

XXVI. ONAGRACEÆ. *Evening Primrose Family.*

230. *Circœa alpina,* Linn. *Mountain* or *Alpine Enchanter's Nightshade.* Flat Bay Brook (R. Bell); (Reeks); rocky banks, Manuel's River (Robinson and Schrenk); near Green's Harbour (A. C. W.) August.

231. **Epilobium latifolium,* Linn. (McGill Coll. Herb. Cat. I., 169). *Lab:* Amour Bay (S. R. Butler); Battle Harbour and L'anse au Mort (A. C. W.—Macoun and Fowler); Hopedale (Weiz). [Cat. I., 129; Packard]. August. Sea-beech.

232. *E. spicatum.* Law. *E. angustifolium.*) *Fireweed, Narrow-leaved Willow Herb*). (Cat. I., 168), Common in Newfoundland, especially in burnt woods. *Lab:* Various places in Southern Labrador and Sandwich Bay (A. C. W.); Hopedale (Weiz); (Hooker); Nain and Nachvak (R. Bell—Packard). August. *Flora Miq.* Damp places or more often dry. Common. July, August.

233. *E. adenacaulon,* Haussk. (E. coloratum, Muhl and E. tebagenum, Linn.) Port à Port and Brigus (R. Bell); banks of South Arm, Holyrood, and rocky banks of Rennie's River, S. John's (Robinson and Schrenk); Englee, Couche, South Dildo (A. C. W.); (McGill Coll. Herb. Cat. I., 169; III., 530). July and August. *Lab:* L'anse au Clair and S. Michaels (A. C. W.—Fowler and Macoun). August. *Flora Miq.* Stony places; common. August.

234. *E. palustre,* Linn. *Marsh Willow herb.* (Reeks); Conche and New Harbour (A. C. W.); Bally Heilly Bog, S. John's (Robinson and Schrenk). August. *Lab:* (Morrison. Cat. II., 459); Hopedale (Weiz); [Packard]; Pack's Harbour, Forteau, Blanc Sablon, Battle Harbour and Mullin's Cove (A. C. W.—Fowler and Macoun). August. *Flora Miq.* Marsh or wet places; common. August.

Var: *Lineare,* Gray. New Harbour (A. C. W.)

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*The nomenclature of the Epilobium genus adopted is that given by Prof. Macoun in his "contributions from the Herb of Geol. Survey of Canada," II., p. 80; based upon its revision by Dr. Wm. Trelease: that is, as far as was possible to the writer.

Labradorica, Haussk. Moist places on rocky hills, S. John's (Robinson and Schrenk). August.

235. *E. alpinum,* Linn. *Alpine Willow Herb.* (Reeks). *Lab:* South Coast (Brunet. Cat. I., 169); wet places at Forteau (S. R. Butler); Cape Chudleigh (R. Bell. Cat. III., 530); Hopedale (Weiz) [Packard]. *Flora Miq.* Mentioned by Southier but not met with.

236. *E. Hornemanni,* Reichenb. *Lab:* Pinware River, Cartwright, Forteau, Blanc Sablon and Pack's Harbour (A. C. W. —Fowler, Eaton and Macoun). July, August. Wet places.

237. *E. anagallidifolium,* Lan. *Lab:* Cape Chidley (R. Bell; contributions from Herb. of Geol. S. of Canada, II., 85).

238. *E. strictum,* Muhl. (E. molle, Torr.) Pipe Stone Road, Bay Despair, Hermitage Bay (Jas. Howley—Macoun).

239. *Ænothera biennis,* Linn. *Common Evening Primrose.* Ferryland or White Bay (Revd. R. Temple—Fowler); near Badger Brook, Exploits (Revd. J. V. Bull—Fowler); New Harbour and Harbour Breton (A. C. W.) July.

240. *A. pumila,* Linn. *Dwarf Evening Primrose.* South Dildo (A. C. W.) July.

XXVII. UMBELLIFERÆ. *Parsley Family.*

241. *Archangelica atropurpurea,* Hoffm. *Great Angelica.* (Reeks). West Coast (R. Bell. Cat. I., 185); confluence of Exploits and Badger Rivers (Robinson and Schrenk). August. *Lab:* South coast of Amour Bay and Caribou Island (S. R. Butler); Hopedale (Weiz—Packard); Battle Harbour (A. C. W.) September.

242. *A. Gmelini,* D. C. *Lab:* (McGill Coll. Herb. Cat. I., 186); Straits of Belle Isle (S. Cyr—Packard); Battle Harbour (A. C. W.) September. *Flora Miq.* Damp places; common. July.

243. *Carum carui,* Linn. *Garden Carraway.* S. John's (Miss Southcott—Macoun); Green's Harbour (A. C. W.) *Lab:* Smack Cove and Cape Charles (A. C. W.) Sept.

244. *Conioselinum Canadense,* Torr and Gray. S. George's Bay (Howley—Macoun); New Harbour and Harbour Breton

(A. C. W.); *Lab:* Battle Harbour (J. H. Bull—Macoun); Venison Tickle (A. C. W.) August. *Flora Miq.* Peaty places; common. August.

245. *Cicuta maculata*, Linn. *Spotted Cowbane.* New Harbour Brook (A. C. W.)

246. *C. bulbifera*, Linn. *Narrow-leaved Hemlock.* West of Random (Cormack).

247. *Dancus carota*, Linn. *Carrot.* (Reeks).

248. *Heracleum lanatum*, Michx. Downy or Cow Parsnip (Health root or Hell trot). Common in many places. *Lab:* (Cat. I., 187); fairly frequent in Straits of Belle Isle and northwards (A. C. W.); Caribou Island (S. R. 'Butler), (Hooker), [Packard]. *Flora Miq.* Damp and sandy places; very common. July, August.

249. *Ligusticum Scoticum*, Linn. *Scotch Lovage* (Cat. I., 184); West of Random (Cormack); Placentia, crevices of cliffs (Robinson and Schrenk); New Harbour and various other places (A. C. W.) August. *Lab:* (Brunet. Cat. I., 184); Caribou Island (S. R. Butler); Battle Harbour, Capstan Island, etc., (A. C. W.—Macoun and Fowler). August, September. Sea cliffs. *Flora Miq.* Dry or damp places; very common. July.

250. *Osmorrhiza brevistylis*, D. C. *Hairy Sweet Cicely.* *Lab:* Capstan Island and Forteau (A. C. W.—Fowler). August. Low woods.

251. *Sanicula Canadensis*, Linn. *Canada Sanicle.* (Reeks).

252. *S. Marylandica*, Linn. (Cat. I., 179); banks of Exploit. River and confluence of Badger Brook (Robinson and Schrenk). August.

253. *Sium cicutæfolium*, Gmelin. *Water Parsnip.* New Harbour Brook (A. C. W.), shallow water and muddy banks, Whitbourne (Robinson and Schrenk). August, Oct.

254. *Selinum Benthami*, Wats. *Lab:* (Morrison. Cat. I., 185.)

XXVIII. ARALIACEÆ. *Ginseng Family.*

255. *Aralia racemosa*, Linn. *Spikenard, Pelly Morrel.* (Reeks). A doubtful specimen from Englee (A. C. W.—A. H. MacKay.)

256. *A. hispida*, Vent. *Dwarf Elder* (Cat. I., 189); barrens at confluence of Exploit and Badger Rivers (Robinson and Schrenk); Topsail (Prof. Holloway—Macoun). August.

257. *A. nudicaulis*, Linn. *Wild Sarsaparilla.* Near Flat Bay Brook (R. Bell); (Reeks); St. John's, rocky hills (Robinson and Schrenk); several places about New Harbour and Harbour Breton (A. C. W.) August. *Flora Miq.* Peaty places, often sterile. July.

XXIX. CORNACEÆ. *Dogwood Family.*

258. *Cornus Canadensis.* Linn. *Dwarf Cornel or Bunchberry.* (Cracke or *Bunchberry.*) "Very abundant in cold sandy woods from the Atlantic to the Pacific" (Cat. I., 190). June, July. *Lab:* Common on the Straits of Belle Isle and northwards (A. C. W.) *Flora Miq.* Very common. June, July.

259. *C. Suecica*, Linn. *Lapland Cornel.* (Morrison. Cat. I., 190); Great Cod Roy Island. Grows everywhere in profusion with the last; quite as common as that all along the N. West and on North Shore, nearly as far as Point de Monts (R. Bell); common at Cow Head (Reeks); at Harbour Breton, Brunet, New Harbour and Exploits (A. C. W.—Macoun and Fowler). July, August. *Lab:* Common everywhere (S. R. Butler); Nain (R. Bell); Hopedale (Weiz), [Packard]. July, August. *Flora Miq.* Heathlands, somewhat moist; very common. June, July.

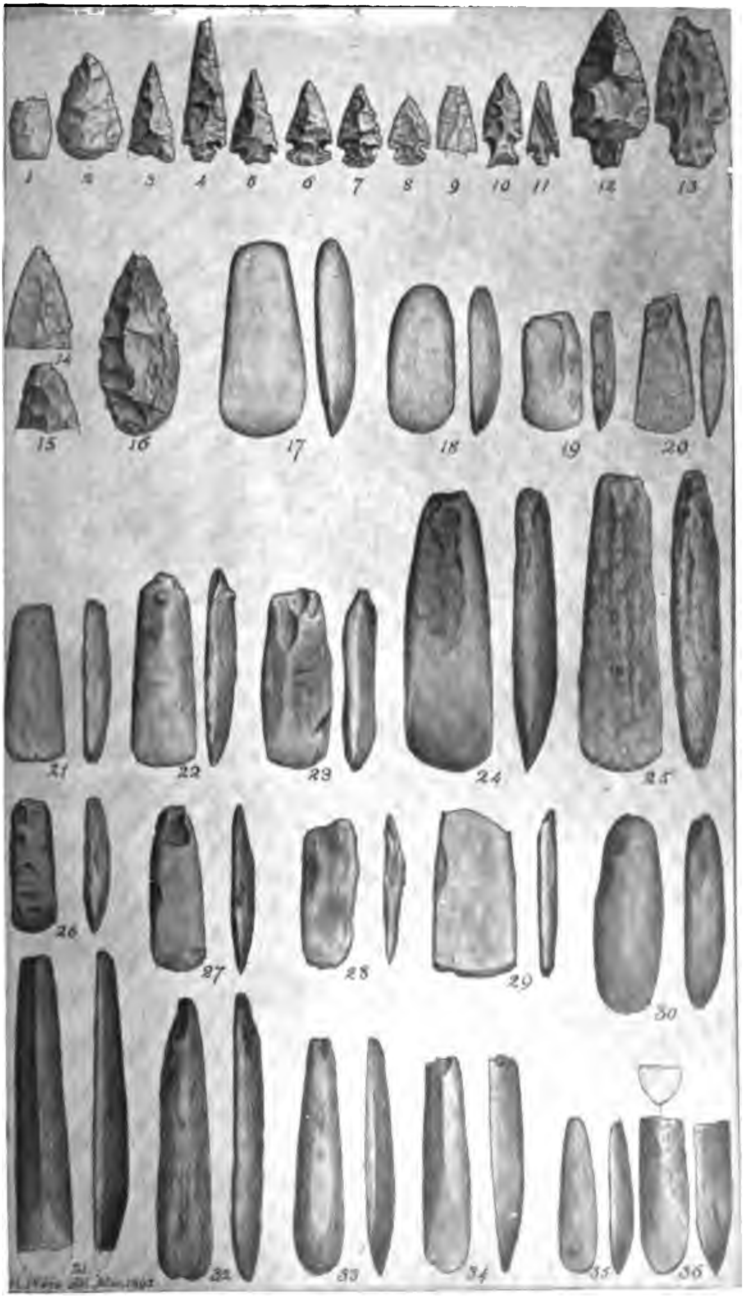
260. *Cornus circinata*, L'Her. *Round-leaved Cornel or Dogwood.* Trinity Bay (Cormack); Great Cod Roy River (R. Bell).

261. *C. sericea*, Linn. *Silky Cornel.* (Reeks).

262. *C. stolonifera*, Michx. *Red Brier, Kinnikinnik (Red Rod).* Appears to be frequent in many places; Great Cod Roy River (R. Bell); (Reeks); New Harbour, Harbour Breton and White Bay (Macoun and Fowler). July. *Flora Miq.* Rare. July.

263. *C. paniculata*, L'Her. *Panicled Cornel* (Reeks).

264. *C. alternifolia*, Linn. *Alternate-leaved Cornel.* Cairn Mountain, Flat Bay (R. Bell). July.



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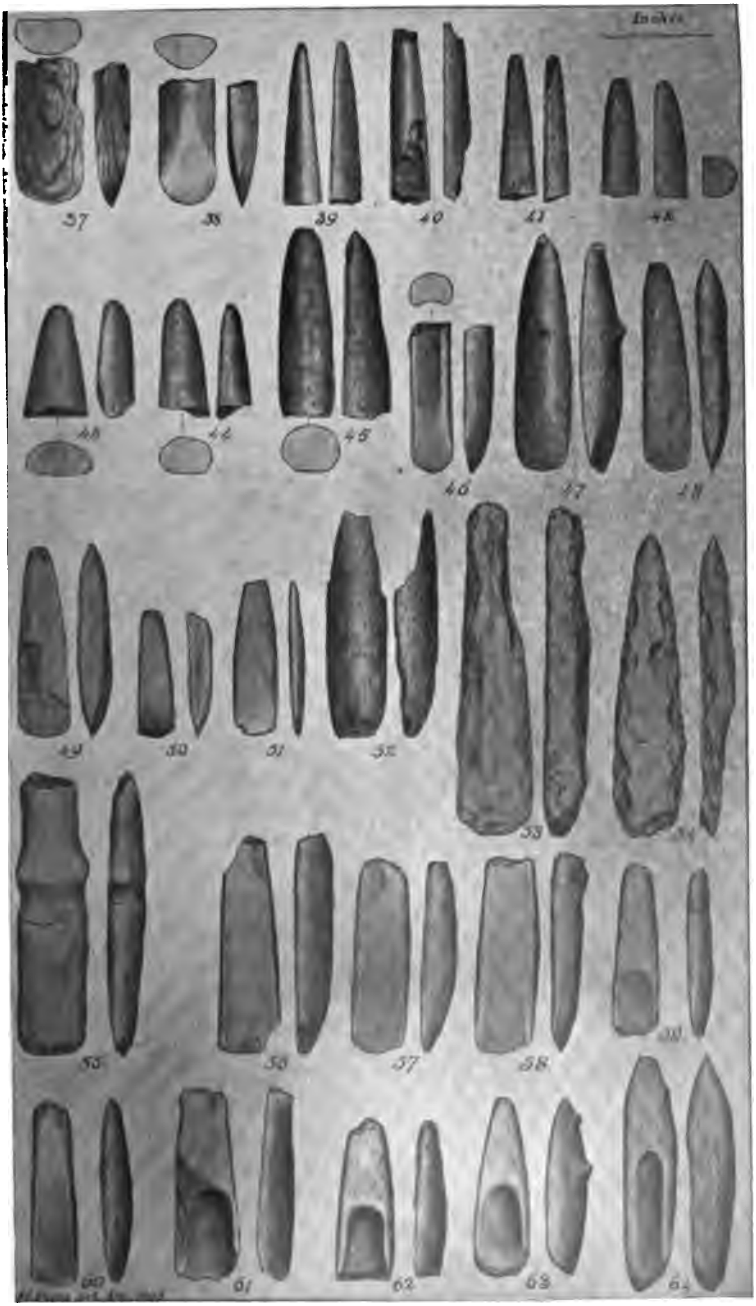

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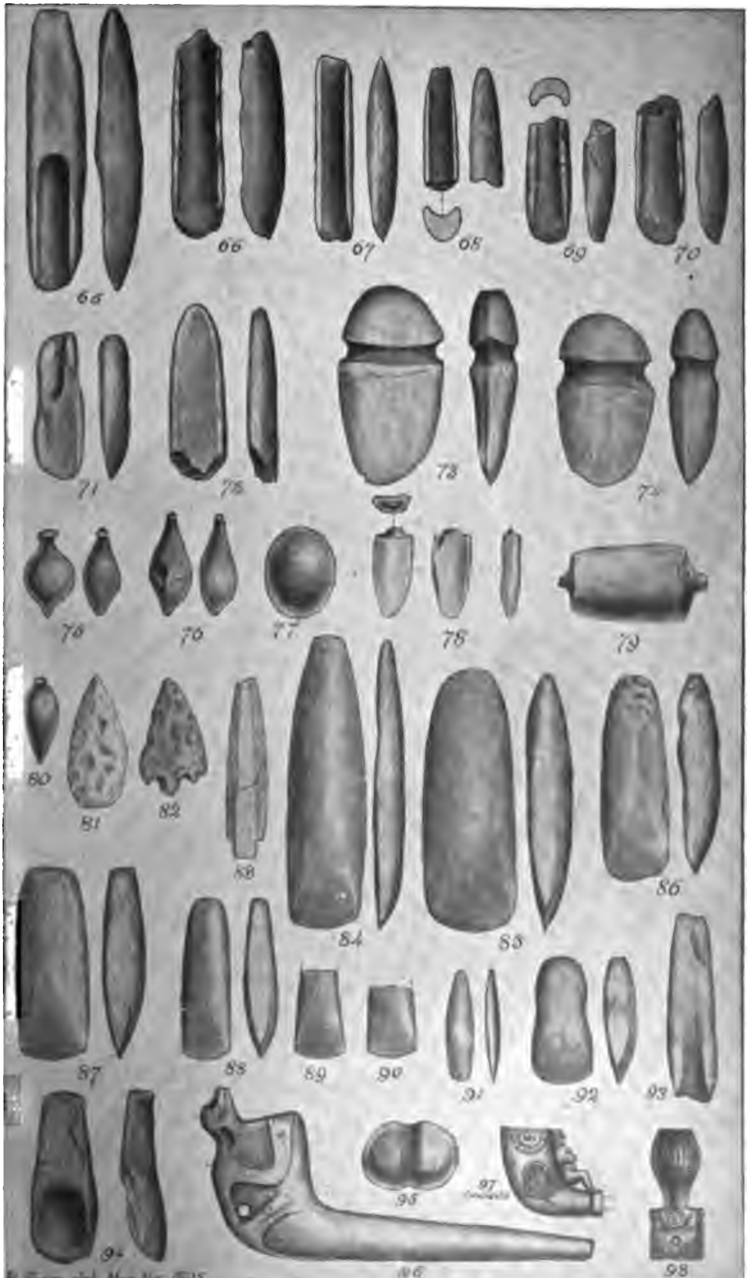

Illustrating Mr. Piers' Paper: "*On Relics of the Stone Age in Nova Scotia.*"

ENTRANCE TO PETITE PASSAGE, NORTH SIDE.

Illustrating Prof. Bailey's Paper: "*On the Geology and Botany of Digby Neck.*"

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1895-96.

I.—On the Calculation of the Conductivity of Mixtures of Electrolytes.—By Prof. J. G. MacGregor, *Dalhousie College, Halifax, N. S.*

(Read 9th December, 1895.)

Arrhenius has deduced* as one of the consequences of the dissociation theory of electrolytic conduction, that the condition which must be fulfilled in order that two solutions of single electrolytes, which have one ion in common, and which undergo no change of volume on being mixed, may be isohydric, *i. e.*, may on being mixed undergo no change in their state of dissociation, is, that the concentration of ions (*i. e.*, the number of dissociated molecules per unit of volume) shall be the same for both. He obtained this result by combining the equations of kinetic equilibrium for the constituent electrolytes before and after mixture. As I shall have occasion to refer to these equations below, I may give them here.

Let P_m Q and P_n R be the general chemical formulæ for two electrolytes having the ion P in common; let v_1 and v_2 be the

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*Ztschft. f. physikalische Chemie, ii, p. 284, (1888.)

volumes of the solutions of these electrolytes which are mixed; let them contain N_1 and N_2 gramme-molecules of the electrolytes respectively; and let α_1 and α_2 be the respective coefficients of ionisation in the constituent solutions, and therefore, if the solutions are isohydric, in the mixture also. Then, according to the dissociation theory of electrolysis and the more general theory of solutions on which it is based, the condition that there shall be equilibrium between the undissociated and the dissociated parts of the electrolytes in the simple solutions, is expressed in the equations:—

$$c_1 \frac{N_1 (1-\alpha_1)}{v_1} = \left(\frac{m \alpha_1 N_1}{v_1}\right)^m \frac{\alpha_1 N_1}{v_1},$$

$$c_2 \frac{N_2 (1-\alpha_2)}{v_2} = \left(\frac{n \alpha_2 N_2}{v_2}\right)^n \frac{\alpha_2 N_2}{v_2},$$

where c_1 and c_2 are constants, *i. e.*, are independent of the values of N, v, and α. The condition that there shall be equilibrium between the dissociated and undissociated parts of each electrolyte after the mixture, in the case of isohydric solutions which do not change either in ionisation or in volume on mixing, is expressed in the following equations:

$$c_1 \frac{N_1 (1-\alpha_1)}{v_1+v_2} = \left(\frac{m \alpha_1 N_1 + n \alpha_2 N_2}{v_1 + v_2}\right)^m \frac{\alpha_1 N_1}{v_1+v_2},$$

$$c_2 \frac{N_2 (1-\alpha_2)}{v_1+v_2} = \left(\frac{m \alpha_1 N_1 + n \alpha_2 N_2}{v_1 + v_2}\right)^n \frac{\alpha_2 N_2}{v_1+v_2}.$$

It follows from the first and third of these equations, that

$$\frac{m \alpha_1 N_1 + n \alpha_2 N_2}{v_1+v_2} = \frac{m \alpha_1 N_1}{v_1},$$

and from the second and fourth, that

$$\frac{m \alpha_1 N_1 + n \alpha_2 N_2}{v_1+v_2} = \frac{n \alpha_2 N_2}{v_2}.$$

Hence,

$$\frac{m \alpha_1 N_1}{v_1} = \frac{n \alpha_2 N_2}{v_2};$$

i. e., the amount of the common ion which is dissociated per unit of volume, must be the same in both constituent solutions.

According to the dissociation theory, the specific conductivity of a mixture of two solutions of electrolytes 1 and 2, whose volumes before mixing were v'_1 and v'_2 respectively, which contained n_1 and n_2 gramme-equivalents of the electrolytes per unit of volume, whose combined volume after the mixture is $p\ (v'_1 + v'_2)$, whose co-efficients of ionisation after mixing are α_1 and α_2, and whose specific molecular conductivities at infinite dilution, under the circumstances in which they exist in the mixture, are $\mu_{\infty 1}$ and $\mu_{\infty 2}$, is given by the expression:

$$k = \frac{1}{p\ (v'_1 + v'_2)} \left(\alpha_1\ n_1\ v'_1\ \mu_{\infty 1} + \alpha_2\ n_2\ v_2'\ \mu_{\infty 2} \right).$$

Since in any case in which isohydric solutions are mixed without change of volume, n_1, v'_1, n_2 and v'_2 are known, α_1 and α_2 readily determinable, and p equal to unity, the specific conductivity can be calculated, provided we may assume that $\mu_{\infty 1}$ and $\mu_{\infty 2}$ have the same values in the mixture as in simple solutions. In the particular case in which equal volumes of the constituents are mixed without change of volume, the conductivity of the mixture becomes obviously the mean of the conductivities of the constituent solutions.

Arrhenius has subjected the result referred to above to a number of tests. In one he determined by experiment several series of dilute aqueous solutions of different single acids, such that if any two of the members of the same series were mixed in equal volumes, the mixture was found to have a conductivity equal to the mean of the conductivities of the constituents. Regarding the solutions of each series as shewn thereby to be isohydric among one another, he calculated the concentrations of the ions in the various solutions by the aid of Ostwald's observations of the conductivity of acids. The following table gives the result, the numbers specifying the concentration of dissociated hydrogen (in mgr. per litre) in the different solutions, and those

in each row applying to solutions found as above to be isohydric with one another:

$H\,Cl$	$(COOH)_2$	$C_4\,H_6\,O_6$	$HCOOH$	$CH_3\,COOH$
151.5	152.6	......	.....	......
42.3	35.1	......	......	......
22.03	21.37	19.07	.....	......
4.48	4.09	4.17	4.42	3.96
1.33	1.24	1.25	1.44	1.33
0.379	0.397	0.381	......	0.402

It will be observed that while the numbers in the various horizontal rows shew a general agreement, they differ very considerably from one another, the extreme differences ranging from 0.7 to 20.5 per cent.

He found also that two solutions of ammonium acetate and acetic acid respectively, which were determined in the above way to be isohydric with one another, contained, according to Kohlrausch, amounts of the ion $C\,H_3\;C\,O\,O$ which were in the ratio 1 : 0.79, a ratio which is only very roughly equal to unity.

So far as result is concerned, these tests are not satisfactory; but the lack of agreement may have been due to various causes: (1) the data for calculation may have been defective, (2) the change of volume which would doubtless occur on mixing, even with very dilute solutions, may have been too great for the application of Arrhenius's deduction, and (3) the difference between the values of μ_∞ in simple solution and in a mixture, may be too great to admit of the identification of isohydric solutions by the method employed.

On the other hand, Arrhenius has calculated* the conductivities of two dilute solutions containing in each case given quantities of two acids, employing for this purpose a series of approximations based on his own observations of isohydric

*Wiedemann's Annalen, xxx, p. 73 (1887).

solutions of the acids; and the calculated values were found to agree with those observed to within 0.5 and 0.2 per cent. respectively. So far as result is concerned, this forms a much more satisfactory test than those mentioned above; but the number of calculations is too small to exclude the possibility of accidental agreement.

The calculation of the conductivity of a mixture of electrolytes is so severe a test of the ionisation theory of electrolysis that I have thought it well to try its possibility on a larger scale, especially as a considerable body of material is available for this purpose in the observations of the conductivity of mixtures of solutions of potassium and sodium chlorides made by Bender*. The present paper contains the results of calculations of the conductivities of mixtures determined experimentally by him.

Method of Calculation.

In order to make such calculations by Arrhenius's method, it would be necessary to make a preliminary determination of a number of isohydric solutions of the two salts, and to restrict the calculations to very dilute solutions. They may be made however, without such preliminary experiments, and without such restriction, by employing a more general form of Arrhenius's deduction.

Two electrolytes, which have a common ion and are in a state of equilibrium in the same solution, may be regarded as occupying definite portions of the volume of the solution. If we apply the equilibrium conditions to the parts of the solutions occupied by the respective electrolytes, as well as to the whole solution, we obtain equations which, *mutatis mutandis*, are identical with those obtained by Arrhenius, as indicated above, for the isohydric solutions and their mixture. Thus, if in the equations of equilibrium given above, we take v_1 and v_2 to be the portions of the volume of the mixture occupied by the respective electrolytes, and α_1 and α_2 to be their co-efficients of ionisation in the

*Wiedemann's Annalen, XXII, p. 197, (1884).

mixture, the above equations express the conditions which must be fulfilled that there may be equilibrium between the dissociated and undissociated portions of each electrolyte, both in the part of the mixture occupied by it and throughout the whole volume of the mixture. The result:

$$\frac{m\ a_1\ N_1}{v_1} = \frac{n\ a_2\ N_2}{v_2},$$

states that in a mixture of solutions of two electrolytes which have a common ion, and are in a state of equilibrium, the concentration of the ions of the respective electrolytes per unit volume of the portions of the mixture occupied by them, must be the same.

With the aid of this result we can find the ionisation co-efficients of the constituents of mixtures such as Bender examined. For if v'_1 and v'_2 are the volumes of the constituent solutions before mixing, and n_1, n_2 the numbers of gramme-molecules per unit of volume which they contain, it gives us the equation:

$$\frac{a_1\ n_1\ v_1'}{v_1} = \frac{a_2\ n_2\ v_2'}{v_2} \quad \ldots\ldots\ldots \quad (1)$$

We have also

$$v_1 + v_2 = p\,(v_1' + v_2') \quad \ldots\ldots\ldots \quad (2)$$

and as the co-efficients of ionisation are functions of the dilution only, at constant temperature, we have

$$a_1 = f_1\left(\frac{v_1}{n_1\ v_1'}\right) \quad \ldots\ldots\ldots \quad (3)$$

$$a_2 = f_2\left(\frac{v_2}{n_2\ v_2'}\right) \quad \ldots\ldots\ldots \quad (4)$$

Of the quantities involved in these equations, n_1, n_2, v_1', v_2' are known, and p may be determined by density measurements before and after mixture. The form of the functions in (3) and (4) may be determined if measurements of the conductivities of sufficiently extended series of simple solutions of the constituent electrolytes are made. We have thus four equations with but four unknown quantities.

If we employ the symbol V to represent the dilution $(v/n\ v')$ we may write the above equations as follows :—

$$\frac{a_1}{V_1} = \frac{a_2}{V_2} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$V_1 + \frac{n_2\ v_2'}{n_1\ v_1'}V_2 = p\left(V_1' + \frac{n_2\ v_2'}{n_1\ v_1'}V_2'\right)\ldots\ldots\ldots \text{(2)}$$

which in the case of mixtures of equal volumes becomes

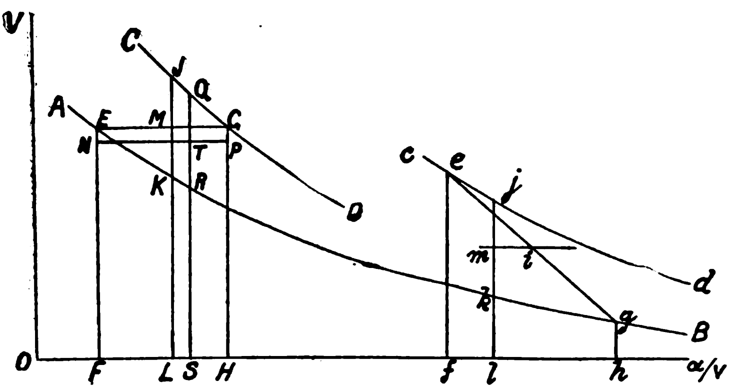
$$V_1 + \frac{n_2}{n_1}\ V_2 = p\left(V'_1 + \frac{n_2}{n_1}V'_2\right),$$

$$\frac{a_1}{V_1} = \phi_1\ (V_1)\quad\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

$$\frac{a_2}{V_2} = \phi_2\ (V_2)\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

I determined α_1 and α_2 from these equations by the following graphical process :—Equation (3) was employed by drawing, from experimental data, for simple solutions of electrolyte 1, a curve having values of the concentration of the ions (α/V) as abscissæ and corresponding values of the dilution (V) as ordinates. This curve was drawn once for all, and was used in all determinations. The curve embodying equation (4) had to be drawn anew, (or rather such portion of it as was necessary), for each mixture examined. In the case of a mixture of solutions containing n_1 and n_2 gramme-molecules per unit volume of electrolytes 1 and 2 respectively, the curve had as abscissæ the concentrations of ions of a series of simple solutions of electrclyte 2, and as ordinates, since Bender's mixtures were mixtures of equal volumes, n_2/n_1 times the corresponding values of the dilutions. Were the mixtures under consideration mixtures of unequal volumes, n_2v_2'/n_1v_1' times the values of the dilutions would have to be used as the ordinates. Equations (1) and (2) were applied by finding, by inspection, two points, one on each of the above curves having a common abscissa $(\alpha_1/V_1 = \alpha_2/V_2)$ and having ordinates (V_1 and $\frac{n_2}{n_1}V_2$ respectively) of such magni-

tude as to have a sum equal to p times the sum of the ordinates of the points on the curves determined by the dilutions (V_1' and V_2' respectively) before mixing. The value of the abscissa common to the two points thus determined, gives the concentrations of ions of both constituents in the mixture. The corresponding ordinate of the first curve, and that of the second curve multiplied by n_1/n_2, give the dilutions (V_1 and V_2) of the constituents in the mixture. The products of the common value of α/V into V_1 and V_2 are the required values of α_1 and α_2 respectively.



The above process will be more readily understood by reference to the accompanying diagram. A B is the curve whose abscissæ are the values of α/V and whose ordinates are the corresponding values of V for a series of solutions of electrolyte 1. If we are to determine the concentration of ions in a mixture of equal volumes of solutions of electrolytes 1 and 2 respectively, we draw the curve C D whose abscissæ are the values of α/V and whose ordinates are n_2/n_1 times the corresponding values of V, for a sufficiently extended series of solutions of electrolyte 2. Let O F and F E represent the concentration of ions and the dilution (V_1') of the solution of electrolyte 1 which is to be mixed with an equal volume of a solution of electrolyte 2, and let O H and H G represent the concentration of ions and

n_2/n_1 times the dilution (V'_2) of the latter solution. Then, since

$$V_1' = \frac{v_1'}{n_1\, v_1'} = \frac{1}{n_1}, \text{ and } V'_2 = \frac{v_2'}{n_2\, v_2'} = \frac{1}{n_2},$$

we have

$$V_1' = \frac{n_2}{n_1} V_2'.$$

Hence F E and H G are equal. In order to determine the concentration of ions after mixing, we must find two points J, K, on the curves A B and C D respectively, having according to equation 1, a common abscissa O L, and having according to equation 2, ordinates L K and L J which together are equal to p times the sum of F E and H G. If p is equal to unity (*i. e.*, if the change of volume on mixing is negligible), the line J K joining the points J and K, when properly selected, will obviously be bisected by the line E G. The points J and K may thus be easily found by inspection. If p is not equal to unity, we must cut off from F E and H G or from these lines produced, portions F N and H P, equal to p. F E and p. H G respectively. Then, as before, the proper points Q, R will be so situated that the line Q R will be bisected by the line N P. Thus in this case also the points Q, R may readily be found by inspection. The points J, K (or Q, R) being thus found, O L (or O S) will represent the common concentration of ions in the mixture, and L K and L J (or S R and S Q) will represent the dilution of electrolyte 1, and n_2/n_1 times the dilution of electrolyte 2, respectively, in the mixture.

If the solutions to be mixed have unequal volumes (v_1' and v_2') we must draw the curve *c d* having as abscissæ the concentrations of ions, and as ordinates $\frac{n_2\ v_2'}{n_1\ v_1'}$ times the corresponding dilutions of a series of solutions of electrolyte 2. Let *Oh* and *hg* represent the concentration of ions, and the dilution (V_1') respectively, of the solution of electrolyte 1, which is to be mixed with a solution of electrolyte 2, and let *Of* and *fe* represent the concentration of ions, and $\frac{n_2\ v_2'}{n_1\ v_1'}$ times the dilution (V_2') of the latter solution, respectively.

From the equations

$$V_1' = \frac{1}{n_1}, \text{ and } V_2' = \frac{1}{n_2},$$

it follows that

$$V_1' : \frac{n_2}{n_1}\frac{v_2'}{v_1'} V_2' = v_1' : v_2'.$$

Hence $f\ e$ and $h\ g$ being proportional to the volumes of the solutions before mixing will be unequal. As before, we have to determine points j and k on curves $c\ d$ and A B respectively, having a common abscissa $O\ l$ and so situated that if p is equal to unity,

$$k\ l + j\ l = e\ f + g\ h,$$

and if p is not equal to unity,

$$k\ l + j\ l = p\ (e\ f + g\ h).$$

If, in cases in which p is equal to unity, the points j, k be properly selected, it is obvious that a line $i\ m$ drawn through i the point of bisection of $e\ g$, parallel to the axis of ionic concentrations, $O\ h$, will bisect $j\ k$. Hence the points j, k, will be easily determined by inspection. If p is not equal to unity, the points corresponding to j and k may be determined by proceeding in a manner similar to that used in the case of a mixture of equal volumes of the constituent solutions. To avoid complication the construction is not inserted in the diagram.

It will be obvious that the values of α_1 and α_2 for a solution containing two electrolytes with a common ion, may be determined in the above way, whether it has been formed by the mixing of two simple solutions or not. It may always be imagined to have been formed in this way, and in cases in which p is not negligible, if data are not available for its determination, special density measurements may be made.

Data for the Calculations.

Bender's paper contains all the data required for the calculation of the conductivities of mixtures of solutions of potassium and sodium chlorides, with the single exception of the specific

molecular conductivity of the simple solutions at infinite dilution. Owing to the want of this datum, I have drawn the curves $a/V = \phi(V)$ by means of data based on Kohlrausch and Grotrian's and Kohlrausch's *observations of the conductivity of solutions of these salts. They are as follows :—

NaCl Solutions.

Concentration Gramme-molecules per litre.	Specific molecular conductivity.	Dilution Litres per Gramme-molecule.	Concentration of Ions.
0.5	757	2	0.3682
0.884	710.42	1.1312	0.6109
1	695	1	0.6761
1.830	618.59	0.5465	1.1012
2.843	539.93	0.3517	1.4932
3	528	0.3333	1.5418
3.924	466.35	0.2548	1.7802
5	398	0.2	1.936
5.085	392.53	0.1967	1.9416
5.325	377.65	0.1878	1.9562
5.421	371.95	0.1845	1.9611

KCl Solutions.

Concentration Gramme-molecules per litre.	Specific molecular conductivity.	Dilution Litres per Gramme-molecule.	Concentration of Ions.
0.5	958	2	0.3939
0.691	933.43	1.4472	0.5304
1	919	1	0.7558
1.427	890.70	0.7008	1.0452
2.208	855.52	0.4529	1.5535
3	827	0.3333	2.0409
3.039	823.95	0.3291	2.0592
3.213	817.94	0.3112	2.1612

It will be seen that the above data are quite sufficient for drawing the curves representing a/V as $\phi(V)$ in the parts corresponding to small dilutions ; but that the data are few for the parts corresponding to the greater dilutions, where the curvature is more rapid. In order to draw these parts of the curves therefore, I obtained interpolation formulæ, expressing a/V

*Wiedemann's Annalen, VI, p. 37 (1879) and XXVI, p. 195, (1885).

in the case of each salt in terms of reciprocals of powers of V. In obtaining these formulæ, I made use of Kohlrausch's data only, Kohlrausch and Grotrian's data not being at the time available to me. As the experimental data from which the formulæ were obtained, applied to a much greater range of dilution than that of the parts of the curves in the drawing of which these formulæ were used, I did not think it necessary to re-determine the formulæ when Kohlrausch and Grotrian's observations came into my hands. The following tables shew the accuracy with which the formulæ reproduced the experimental data on which they were founded:

Dilution (V).	Concentration of Ions (a/V) Calculated From	
	Kohlrausch's Observations.	Formula.
NaCl Solutions.		
10	0.08414	0.08413998
2	0.3682	0.3681999
1	0.6761	0.6760998
$0.\dot{3}$	1.5418	1.541798
0.2	1.9360	1.936008
KCl Solutions.		
10	0.08610	0.086099
2	0.3939	0.393900
1	0.7558	0.755802
$0.\dot{3}$	2.0409	2.01088

As the formulæ, owing to the narrow range of their applicability, are of no permanent value, they need not be given here. The consistency of the results of the calculations based on them, as given in the table below, would seem to show that they were sufficiently accurate for the purpose in hand.

As Bender measured the specific gravities of both his simple solutions and his mixtures, his paper affords the necessary data for determining the change of volume on mixing. Such change

will have a double effect on the calculated conductivity, (1) affecting the value of a as determined from the curves, and (2) introducing the factor p in the final computation. In the case of Bender's solutions, though in some cases they were nearly or quite saturated, the first effect was so small as to be much less than the error incidental to the graphical process, and I did not therefore take it into account. The second effect was also very small; but as in some cases it was nearly as great as Bender's estimated error, I took it into account in all the calculations.

While Kohlrausch's solutions had at 18°C both the constitution and the conductivity specified in his tables, Bender's solutions had at 15° the constitution, and at 18° the conductivity ascribed to them. I found that it did not appreciably affect the values found for a_1 and a_2 to regard the concentrations at 15° as being the concentrations at 18°, but that this approximation was inadmissible in calculating the conductivity, as in some cases it made a difference of about the same magnitude as Bender's estimated error. Hence in the calculations, I took as the values of n_1 and n_2, Bender's values multiplied by the ratio of the volume of the solution at 15° to its volume at 18°. As Bender measured the thermal expansion of his solutions, his paper furnishes the necessary data for this correction.

The conductivities given by Bender as the results of his observations are the actual results of measurement, and are thus affected by accidental errors, which in some cases are considerable. In order that his observations might be rendered comparable with the results of calculation, these accidental errors must as far as possible be removed. I therefore plotted all his series of observations on co-ordinate paper, drew smooth curves through them, and estimated as well as I could, in this way. the accidental errors of the single measurements. The corrections thus determined are given in the table below in the column headed: Correction *a*.

Bender himself draws attention to certain differences between his observations of the conductivity of simple solutions of K Cl and Na Cl, and those for solutions of the same strength con-

tained in Kohlrausch's tables of interpolated values, ascribing them (1) to his own observations being the results of actual measurements, and (2) to the different temperatures at which their respective solutions had the specified strength. These differences are shewn in the following table :—

Salt in Solution.	Conductivity.		Difference.
	Bender.	Kohlrausch.	
Na Cl.	388	380	+ 8
K Cl.	478	471	+ 7
Na Cl.	702	698	+ 4
K Cl.	916	911	+ 5
Na Cl.	977	974	+ 3
Na Cl.	1217	1209	+ 8
K Cl.	1362	1328	+34
Na Cl.	1425	1412	+13
Na Cl.	1594	1584	+10
K Cl.	1741	1728	+13
Na Cl.	1745	1728	+17
Na Cl.	1845	1846	- 1
K Cl.	2106	2112	- 6
K Cl.	2484	2480	+ 4
K Cl.	2820	2822	- 2

It will be noticed that the differences are all of the same sign up to conductivities of about 1800, and nearly all of the opposite sign for higher conductivities ; also, that for any given conductivity the difference is of the same sign and of about the same magnitude for solutions of both salts. If they were due to the first of the above causes, since Kohlrausch's interpolated values agree well with his observations we should expect more alternation of sign ; if to the second, there should be no change of sign ; if to both, there should be greater and more irregular variation in the magnitude. The fact that the differences are practically the same for both electrolytes at any given value of the conductivity would seem to show that the cause of the differences, a defect in the apparatus possibly, or in the distilled water, was operative in the measurements of both sets of simple solutions, and therefore probably in the measurements of the mixtures. Hence, to render the results of calculations based on Kohlrausch's data for the simple solutions, comparable with Bender's results for

mixtures, we must determine what the conductivities of Bender's mixtures would have been if Kohlrausch had prepared and measured them. To find this out as nearly as possible, I plotted the data of the above table with Bender's conductivities as abscissæ, and the differences between them and Kohlrausch's corresponding values as ordinates, and drew a smooth curve through the points. By the aid of this curve I determined the correction b of the table given below. This correction is of course a more or less doubtful one; for it is not certain that the observations on mixtures suffered from the same unknown source of error as the observations on simple solutions. It seems probable however that they did; and the results of the table given below would appear to render it almost certain.

It may be well in one case to give an example of the mode of calculation. We may take for this purpose the mixture of solutions containing each 1 gramme-molecule of salt. It is found by the graphical process that the value of a/V for this mixture is 0.718 gramme-molecules per litre and that the dilutions in the mixture are 0.937 and 1.063 litres per gramme-molecule for the Na Cl and K Cl respectively. The densities of the constituent solutions were 1.0444 and 1.0401 respectively, and that of the mixture 1.0422. The expansions per unit volume between 15° and 20° were 0.0013569 and 0.0012489 respectively. The values of the conductivity at infinite dilution, I took to be 1028 and 1216 respectively, according to Kohlrausch's observations. Hence the conductivity of the mixture

$$k = \frac{1}{2}\,\frac{2 \times 1.0422}{2.0845}\left(\frac{1 \times 0.718 \times 0.937 \times 1028}{1 + 0.6 \times 0.00136} + \frac{1 \times 0.718 \times 1.063 \times 1216}{1 + 0.6 \times 0.00125}\right) = 809.2$$

Bender's observed value (he used the same standard as Kohlrausch) was 814. To this a correction of about -3 must be applied to make the observation agree with the others of the same series (correction a) and a correction of about -3 to make it comparable with a calculated value based on Kohlrausch's data (correction b). Bender's reduced value is thus 808, which differs from the calculated value by 1.2, or 0.15 per cent.

Results of the Calculations.

The following table gives the results of the calculations, the 2nd and 3rd columns containing the numbers of gramme-molecules per litre in the simple solutions at 15°C, the 4th column Bender's observed values of the conductivities of the mixtures, the 5th and 6th, corrections *a* and *b* referred to above, the 7th, Bender's reduced values, the 8th, the calculated values, and the 9th, the excess of the calculated values over those observed, expressed as per-centages of the latter :—

Number.	Constituent solutions:—grm.-molecules per litre.		Conductivity of Mixture.					Diff., per cent.
	Na Cl.	K Cl.	Bender observed.	Corrections, *a*.	Corrections, *b*.	Bender reduced.	Calculated.	
1	0.5	0.1875	291	0	....	291	289.5	-0.52
2	"	0.375	377	0	- 7	370	373.1	+0.84
3	"	0.5	436	0	- 6	430	426.1	-0.90
4	"	0.75	545	0	- 5	540	537.6	-0.44
5	"	1.5	866	0	- 3	863	858.3	-0.54
6	1.0	0.1875	442	+23	- 6	459	461.4	+0.52
7	"	0.375	546	0	- 5	541	540.6	-0.07
8	"	0.75	707	0	- 4	703	701.1	-0.27
9	"	1.0	814	- 3	- 3	808	809.2	+0.15
10	"	1.5	1014	+ 6	- 5	1015	1015.2	+0.02
11	"	2.0	1224	- 6	- 9	1209	1200.6	-0.69
12	2.0	0.1875	776	0	- 3	773	773.9	+0.12
13	"	1.0	1085	0	- 6	1079	1086.3	+0.68
14	"	2.0	1458	0	-13	1445	1458	+0.90
15	"	3.0	1832	- 9	0	1823	1808.6	-0.79
16	3.0	1.0	1332	0	-11	1321	1324	+0.23
17	"	2.0	1674	0	-10	1664	1660	-0.24
18	"	3.0	2003	0	+ 4	2007	1988.7	-0.91
19	4.0	0.375	1367	-10	-12	1345	1350.4	+0.40
20	"	2.0	1857	0	+ 1	1858	1849.3	-0.47
21	"	3.5	2300	0	+ 3	2303	2239.2	-2.77
22	"	4.0	2428	+ 6	- 2	2432	2345.3	-3.56

It will be seen that in the case of the more dilute solutions Nos. 1-17 and 19, the differences, which are in all cases less than

1 per cent., and for the most part considerably less, are one half positive and one half negative, and that whether the solutions are arranged in the order of conductivity, or in the order of mean concentration, they exhibit quite a sufficient alternation of sign to warrant the conclusion that they are due chiefly at least, to errors in the observations and in the graphical portion of the calculations.

In the case of the stronger solutions, Nos. 16-18 and 19-22, the alternation of sign has disappeared. In the weakest solutions of these two series, the differences are positive and small; but as the concentration increases, the differences become negative and take increasing negative values, the negative difference having its greatest value in No. 22, which is a mixture of a strong solution of Na Cl with a saturated solution of K Cl. The tendency towards a negative difference as the concentration increases, may be recognised also in Nos. 11 and 15; and it is perhaps worth noting that while the mean value of the positive differences is slightly greater than that of the negative differences up to a concentration of 1 gramme-molecule of salt per litre, the mean negative difference is the greater for higher concentrations.

It is manifest from these results that for solutions of these chlorides containing less than say 2 gramme-molecules per litre, it is possible to calculate the conductivity very exactly, but that for stronger solutions the calculated value is less than the observed.

The excess of the observed over the calculated conductivities, shews one or more of the assumptions implied in the mode of calculation to be erroneous. It would seem to be probable that the error is at any rate largely due to the assumption that the molecular conductivity of an electrolyte at infinite dilution is the same whether it exists in a simple solution or in a mixture, and that the discrepancy is thus due to the effect of mixing on the velocities of the ions. The mode of calculation assumes that in the mixture the constituents are not really mixed, but lie side by side, so that the ions of each electrolyte in their passage from electrode to electrode travel through the solution to which they

belong only. They must rather be regarded however as passing in rapid alternation, now through a region occupied by one solution, and now through a region occupied by the other. The actual mean velocities of the ions in the mixture will therefore probably differ from their values in a solution of their own electrolyte only. In the case of dilute solutions the difference will be small, in sufficiently dilute solutions inappreciable, but in the case of the stronger solutions it may account in large part for the discrepancy observed above. We have however, so far as I am aware, no data for calculating the effect of mixture on the ionic velocities or the extent to which the discrepancy is due to this effect.

To obtain some rough conception of its magnitude, I have calculated the conductivity of the mixture No. 18, on two assumptions which seemed more or less probable, viz., (1) that the velocities of the ions of each electrolyte in the mixture are the same as they would be in a simple solution of their own electrolyte of a concentration (in gramme-molecules per litre) equal to the mean concentration of the mixture, and (2) that the velocities of the ions of each electrolyte, when passing through a region occupied by the other electrolyte, are the same as they would be in a simple solution of the former of a dilution equal to that of the latter. The expression used for the conductivity wa

$$k=\frac{1}{2\,p}\left(a_1\, n_1\, \mu_{\infty 1}\frac{u_1'}{u_1}+\, a_2\, n_2\, \mu_{\infty 2}\frac{u_2'}{u_2}\right),$$

where u_1 and u_2 are the sums of the velocities of the ions of electrolytes 1 and 2 respectively in simple solutions of the dilutions which they have in the mixture, while u_1' and u_2' are the values these ionic velocities would have according to the particular assumption employed, the velocities in all cases being those corresponding to the same potential gradient. As the graphical process above gave the dilution of each electrolyte in the mixture, the values of u and u' were readily determined by the aid of Kohlrausch's table of ionic velocities.* I found that

*Wiedemann's Annalen, L, p. 385, (1893).

according to assumption (1) the conductivity would be greater than Bender's reduced value by 1.6 per cent. and that according to assumption (2) it would be greater by 1.3 per cent. Similar calculations could not be carried out with solutions stronger than No. 18, owing to lack of data. If the above assumptions be regarded as representing even roughly the effect of mixing on the ionic velocities, the calculations based on them shew that the error introduced by neglecting the effect of mixing would be of the same sign and order of magnitude as the differences between the calculated and observed values of the above table. While, therefore, such calculations are of little value, they strengthen the suspicion that the discrepancies of the above table are due to the impossibility of taking into account the effect of mixing on the velocities of the ions.

II.—On the Calculation of the Conductivity of Mixtures of Electrolytes having a Common Ion. — By Douglas McIntosh, *Physical Laboratory, Dalhousie College, Halifax, N. S.*

(Received April 6th, 1896.)

In a paper read before this Institute some months ago, Prof. MacGregor* shewed how to obtain, by a graphical process, from observations of the electrical conductivity of a sufficient number of simple solutions of two electrolytes having a common ion, the data necessary for the calculation of the conductivity of a solution containing both electrolytes, according to the dissociation theory of electrolytic conduction; and in order to test this theory, he calculated the conductivities of a series of mixtures of solutions of sodium chloride and potassium chloride, which had been measured by Bender. He found that for dilute solutions his calculations agreed with Bender's observations within the limits of experimental error; but that, as the strength of the solution increased the differences became larger, until with a mixture of solutions containing each four gramme-molecules per litre of salt (the strongest solutions with which Bender worked) a difference of 3·6 per cent. was found. The method of calculation assumed that the ionic velocities of the constituent electrolytes, were not changed by the mixing, and Prof. MacGregor attributed the differences between the calculated and observed values, to the change, which, as he pointed out, would probably be produced, in these velocities, by mixture.

At his suggestion I have made the observations described in this paper, with the object of determining (1) what the differences between the observed and calculated values are, in the case of mixtures of sodium and potassium chloride solutions, of greater strength than those examined by Bender, and (2) how the calculated and observed values are related, in the case of

* Trans. N. S. Institute of Science, Vol. IX, p. 101.

solutions containing sodium chloride and hydrochloric acid,—electrolytes whose ionic velocities differ from one another much more than those of sodium and potassium chlorides.

The expression for the conductivity of a mixture of equal volumes of solutions of two electrolytes 1 and 2, which contain n_1 and n_2 gramme-equivalents per unit of volume respectively, the ionisation coefficients of which, in the mixture, are a_1 and a_2, the molecular conductivities of which at infinite dilution are $\mu_{\infty 1}$ and $\mu_{\infty 2}$, and which so change in volume on mixing that the ratio of the volume of the mixture to the sum of the volumes of the constituent solutions is p, is

$$c = \frac{1}{2\,p}\left(a_1\, n_1\, \mu_{\infty 1} + a_2\, n_2\, \mu_{\infty 2}\right).$$

In order to calculate the conductivity of such a mixture therefore. the seven quantities in this expression must be known. The ionisation co-efficients a_1 and a_2 are determined by the graphical process referred to above, from series of observations of the conductivities of simple solutions of the constituent electrolytes. The conductivities at infinite dilution are determined by similar observations with very dilute solutions. The concentrations may be determined by analysis, and the quantity p by density measurements.

I intended at the outset to determine all these quantities myself, in order that the data of calculation might apply to exactly the same electrolytes. But owing to the fact that the electrolytic cell, to be used in the determination of conductivities at infinite dilution, although ordered months ago, did not arrive in time, I am compelled to use Kohlrausch's values of the conductivities at infinite dilution for the electrolytes examined.

Determination of Conductivities.

Kohlrausch's well-known method with the telephone and alternating current was used. The apparatus was supplied by Queen & Co., of Philadelphia, and consisted of a German silver

bridge-wire, about three metres long, wound on a marble drum. The wire was divided into 1000 parts, and had a resistance of about 1.14 ohms. I calibrated it by the method of *Strouhal and Barus, and applied the corrections thus determined to the measured resistances. (The greatest correction that had to be applied during the experiments was one division).

Four coils, marked 1, 10, 100, 1000 true ohms formed part of the apparatus, and were guaranteed correct, to 0.1 per cent The range of the resistances measured during the experiments, however, was so small that I needed to use only one of these coils (that of 100 ohms). Hence it was not necessary for me to test the relative accuracy of the coils. Nor did I need to test the absolute accuracy of the 100 ohm coil, as it was not necessary for me to express conductivities in absolute measure.

The cell used was a U-shaped one, with enlargements for the electrodes, of the kind shown in Ostwald's Physico-chemical Measurements, p. 226, Fig. 178. The cell and also the electrodes (each of which had an area of about 7 sq. cm.), were smaller than ordered, and the latter were so thin as to be easily bent. No change of resistance, however, could be noticed for small bendings of the plates, which could be readily detected by the eye and avoided. The induction coil was quite small, and had a specially rapid vibrator. It was kept in an adjoining room, that the noise might not disturb the operator; but, after some practice it was found that measurements could be made without difficulty, even with considerable noise. Different kinds of batteries for working the coil were tried. The most satisfactory was found to be a small dry battery, made by the Mamisburg Electric Co., of the kind used for electric bells. With this apparatus the "minimum" point on the bridge could be determined by the telephone to within ½ division. This, at the centre of the bridge, meant a possible error of 0.2 per cent., and at the point of the bridge farthest from the centre, used in my experiments, a possible error of 0.3 per cent.

*Wied. Ann., X, p. 326, 1880.

Temperature.

As the laboratory temperature varied considerably from day to day, the electrolytic cell was placed in a bath whose temperature was regulated by a thermostat of the kind described by Ostwald in his Physico-chemical Measurements, p. 59. The resistances measured were so small that a sharp " minimum " was obtained when a water bath was used. There was no necessity therefore, for a petroleum bath. The bath was stirred by a current of air from a small suction pump, and the temperature kept as near to 18°C as possible. When this temperature could not be exactly obtained, measurements of resistance were made at several near temperatures, and the temperature co-efficients found. The co-efficient was always about 2 per cent. per degree.

The thermometer used was graduated to 0.1 degree centrigrade, and could be easily read to 0.05 degree. This meant a possible error of 0.1 per cent. in the determination of the resistance. The errors of the thermometer had recently been determined at the Physikalisch-Technische Reichsanstalt, Berlin.

The Platinizing of the Electrodes.

The electrodes after having been boiled in alkali and acid, were placed in a very dilute solution of chloroplatinic acid ($H_2 Pt Cl_6$) and connected with a small battery, the direction of the current being frequently changed. When the electrodes had become covered with a black velvety coating, they were removed from the cell, and in order to get rid of the chloroplatinic acid which adheres strongly to the platinum black, they were washed several times with boiling water. On one occasion, in the course of the experiments, the minimum point was found to be indistinct. The plates were accordingly replatinized and distinctness found to have been regained. The experiments previously made (those on potassium chloride) may have been affected by a slight error due to defective platinizing.

The Salts and Acids.

The potassium and sodium chlorides, obtained as chemically pure from Eimer and Amend of New York, were further purified

by recrystallization. Solutions of them were found to be neutral and free from sulphates and magnesia. Neither potassium nor other metals could be detected in the sodium chloride with the spectroscope. Sodium, but no other metal, could be detected in a flame coloured by the potassium chloride. The hydrochloric acid was obtained as chemically pure, and gave no residue on evaporation. It was free from sulphates.

The Water Used.

The water was doubly distilled, with addition of sodium hydrate, in a tin-lined retort, and condensed in a block-tin pipe, the first part of the distillate being rejected. It was stored in bottles which had been used for this purpose for several years. It gave no residue when evaporated, was neutral, and gave no colour with Nessler's reagent.

Preparation and Analysis of the Simple Solutions.

The simple solutions were prepared by dissolving about the amount of salt required for the strongest solution, and subsequent diluting. The concentration in each case was determined by volumetric analysis. A solution of silver nitrate was used in estimating the chlorine in the potassium and sodium chlorides, and the amounts of salt present were calculated from the data thus obtained.

In making an analysis 1 c. c. (or 5 c. c.) of the solution at 18°C was drawn off by a pipette, placed in a flask, diluted, and coloured distinctly with neutral potassium chromate. Silver nitrate standardised at 18°C was run in from a burette, and a glass bulb filled with potassium chromate of the same shade as the solution being analysed, was held before the eye. The end point by this means could be seen quite sharply.

A solution of ammonia was employed for estimating the hydrochloric acid, with cochineal as an indicator.

The pipettes and burettes used were tested by weighing the water which they delivered. They were found to be accurate to 0.1 per cent.

To determine the accuracy of the volumetric analysis, a solution of sodium chloride was prepared, containing a known quantity of the pure fused salt. The results of the analyses were found to be correct to 0.1 per cent.

Specific Gravity Determinations.

The object of specific gravity determinations was the finding of p in the above expression for the conductivity. For this purpose it was necessary to find the specific gravity to the third decimal place only. Hence the determinations were made with a Mohr-Westphal balance which read to the fourth decimal place, and might be trusted in the third.

In all the mixtures examined p was found to be practically equal to unity.

Preparation of the Mixtures.

A 50 c. c. pipette which had been carefully washed, and stood on filter-paper for some time, was rinsed out several times with one of the constituents of the intended mixture, whose composition and specific gravity had been determined. The pipette was filled to the mark, and the solution run into a clean and dry bottle. The pipette was then washed, and the other constituent placed in the bottle as before, care being taken to use the pipette in exactly the same manner in both cases. All mixtures were made at 18°C. and the same pipette was used for both solutions, in order that the mixture might consist of exactly equal volumes of them.

The conductivities of solutions were found to increase on standing, which was doubtless due to portions of the glass being dissolved. The conductivities were therefore measured as soon after the solutions were made up as possible.

Capacity of the Electrolytic Cell.

To find the factor which would reduce the observed conductivities to the standard employed by Kohlrausch, viz., the conductivity of mercury at 0°C, the following simple solutions of potassium and sodium chloride were analysed, and their conductivities measured :

Potassium Chloride.		Sodium Chloride.	
Concentration, (Gramme-Molecules per Litre.)	Conductivity, $\times 10^8$.	Concentration, (Gramme-Molecules per Litre.)	Conductivity, $\times 10^8$.
2.07	1854	2.06	1199
2.61	2281	2.56	1517
2.94	2521	2.83	1616
3.26	2767	3.37	1786
3.68	3040	3.70	1876
3.88	3187	4.29	1970
		4.69	2025
		5.12	2087

These values were plotted on co-ordinate paper with concentrations as ordinates and conductivities as abscissæ, and smooth curves were drawn between the points so as to obviate accidental errors. Conductivities were taken off these curves and compared with the numbers given by Kohlrausch* for solutions of equal concentration, as shewn in the following table.

Potassium Chloride.

Concentration (Gramme-Molecules per Litre.)	Conductivity.		Ratio.
	Kohlrausch.	Observed.	
2	1728	1800	.960
2.5	2122	2199	.961
3	2480	2566	.966
3.5	2822	2924	.965

Sodium Chloride.

Concentration (Gramme-Molecules per Litre.)	Conductivity.		Ratio.
	Kohlrausch.	Observed.	
2	1209	1277	.946
2.5	1412	1500	.941
3	1584	1675	.946
3.5	1728	1815	.952
4	1846	1928	.957
4.5	1935	2000	.968
5	1991	2066	.964

*Wied. Ann., Vol. VI, p. 146.

It will be noticed that the ratios in the above table are not the same for all solutions, but are practically the same for solutions of both salts of the same conductivity. The variation of the ratio may have been due to some unknown defect of apparatus or mode of using it; but as this source of error was equally operative in the case of solutions of both salts of the same conductivity, it would probably be equally operative also in mixtures of the same conductivity. Hence in reducing the observed conductivity of a mixture of potassium and sodium chloride solutions to Kohlrausch's standard, the factor employed was the value of the ratio for the conductivity which the mixture was found to have, this ratio being determined from the above table by graphical interpolation. Bender found a similar variation in the ratio of his conductivities of solutions of these salts to Kohlrausch's conductivities for solutions of the same strength.

On comparing the observed conductivities of solutions of hydrochloric acid with conductivities of solutions of equal concentration, as given by Kohlrausch, the ratios were found to be practically uniform and equal to 0.955. In the tables which follow all conductivities are expressed in terms of Kohlrausch's standard.

Conductivities of the Simple Solutions.

In order to obtain the data for the calculations, it is necessary to draw curves giving the relation of the dilution to the concentration of ions in the simple solutions, and therefore to know the concentrations and conductivities of sufficiently extended series of these solutions. In the case of sodium and potassium chlorides sufficient data were available for this purpose in Kohlrausch's observations. The following tables give the dilutions and ionic concentrations of solutions of these salts examined by him.

POTASSIUM CHLORIDE.

DILUTION.	CONCENTRATION OF IONS.	DILUTION.	CONCENTRATION OF IONS.
2	0.3861	0.400	1.7311
1	0.7467	0.333	2.0328
0.666	1.0885	0.285	2.3131
0.500	1.4164		

SODIUM CHLORIDE.

DILUTION.	CONCENTRATION OF IONS.	DILUTION.	CONCENTRATION OF IONS.
2.30	0.3257*	0.500	1.1738
2.00	0.3689	0.400	1.3709
1.80	0.4036*	0.333	1.5378
1.64	0.4378*	0.285	1.6776
1.50	0.4732*	0.250	1.7920
1.20	0.5752*	0.222	1.8783
1.13	0.6109	0.200	1.9320
1.00	0.6777	0.182	1.9596
0.666	0.9456		

*Obtained through Prof. MacGregor's interpolation formula, Trans. N. S. Inst. Sci., Vol. IX, p. 112.

In the case of hydrochloric acid, sufficient data were not available. I therefore made a series of measurements of the concentrations and conductivities of solutions of this acid, the results of which are given in the following table:

Concentration (Gramme-molecules per Litre.)	Molecular Conductivity, $\times 10^8$.	Concentration (Gramme-molecules per Litre.)	Molecular Conductivity, $\times 10^8$.
1.58	2550	2.80	2065
1.93	2403	2.88	2052
2.11	2347	3.15	1960
2.18	2305	3.29	1914
2.24	2290	3.39	1890
2.46	2245	3.60	1789
2.51	2192	3.83	1726
2.56	2164	4.13	1636
2.66	2141	4.55	1534
2.78	2090	4.87	1456

The following table contains values of the dilution and concentration of ions in hydrochloric acid solutions, obtained in

part by graphical interpolation of the above observations, and in part by the aid of Kohlrausch's tables :—

Dilution.	Concentration of Ions.	Obtained.	Dilution.	Concentration of Ions.	Obtained.
2.000	0.4310	Kohlrausch	0.500	1.3600	Observed
1.666	0.5090	"	0.444	1.4660	"
1.428	0.5840	"	0.400	1.5685	"
1.250	0.6567	"	0.364	1.6516	"
1.111	0.7269	"	0.333	1.7229	Kohlrausch
1.000	0.7943	"	0 286	1.8379	Observed
0.800	0.9557	Observed	0.250	1.9132	"
0.666	1.1031	"	0.222	1.9746	"
0.571	1.2370	"			

The values of the specific molecular conductivity at infinite dilution for potassium chloride, sodium chloride, and hydrochloric acid respectively, were taken to be 1220×10^{-8}, 1030×10^{-8} and 3500×10^{-8} according to Kohlrausch's determination.*

Results of Observations on Mixtures.

(A).—Sodium and Potassium Chlorides.

The following series of mixtures of potassium and sodium chloride solutions were examined :

Concentration (Gramme-Molecules per Litre.)		Conductivity $\times 10^8$
K Cl.	Na Cl.	
3.88	5.12	2494
3.20	"	2326
2.49	"	2187
1.93	"	2029
3.88	5.12	2494
"	4.28	2404
"	3.37	2316
"	2.56	2196
"	2.06	2124
3.46	3.20	2160
3.80	2.23	1877

*Wied. Ann., Vol. XXVI, p. 204.

The following table contains a statement of the measured and calculated values of the conductivities of the above mixtures, with the concentrations of the constituent solutions, and the data necessary for the calculations, viz., the dilutions of the respective electrolytes and their ionic concentrations, in the mixtures, these data being obtained by Prof. MacGregor's graphical process. The measured values of the conductivity were obtained from the above observations by graphical interpolation.

Constituent Solutions (Gramme-molecules per Litre.)		Dilution in the mixture.		Concentration of Ions in the Mixture.	Conductivity, $\times 10^8$		Difference, Per Cent.
K Cl.	Na Cl.	K Cl.	Na Cl.		Calculated.	Measured.	
3.75	5.12	.247	.143	2.013	2312	2469	-6.4
3.50	"	.234	.156	1.993	2276	2420	-6
3.00	"	.205	.1855	1.950	2202	2313	-4.8
2.50	"	.175	.216	1.890	2109	2190	-3.7
2.00	"	.151	.239	1.822	2013	2049	-1.7
3.88	5.00	.26	.14	2.014	2323	2481	-6.4
"	4 50	.291	.151	1.998	2295	2429	-5.5
"	4.00	.335	.166	1.980	2292	2377	-3.6
"	3.50	.388	.182	1.955	2261	2324	-2.7
"	3.00	.462	.205	1.916	2227	2260	-1.4
"	2.50	.573	.227	1.864	2174	2189	-0.7
"	2.00	.750	.250	1.788	2096	2116	-1.0
3.46	3.12	.412	.2295	1.848	2130.5	2160	-1.3
2.23	3.80	.2432	.2824	1.68	1875.5	1877	-0.08
2.87	4.69	.225	.202	1.924	2177	2222	-2

The results of Bender's experiments, as calculated by *Prof. MacGregor, are given below for comparison.

Concentration (Gramme-molecules per Litre.)		Conductivity.		Difference, Per Cent.
K Cl.	Na Cl.	Measured.	Calculated.	
2.0	2.0	1445	1458	+0.90
3.0	2.0	1823	1808.6	-0.79
2.0	3 0	1664	1660	-0.24
3.0	3.0	2007	1988.7	-0.91
2.0	4.0	1858	1849.3	-0.47
3.5	4.0	2303	2239.2	-2.77
4.0	4.0	2432	2345.3	-3.56

*Trans. N. S. Institute of Science, Vol. IX, p. 101.

The two sets of observations agree very well together, the differences between calculated and observed values being of the same sign and in general for mixtures of about the same mean concentration, of approximately the same magnitude.

The two series of mixtures of strong solutions shew that the differences increase rapidly as the constituent solutions are more and more nearly saturated, reaching in the case of practically saturated solutions 6.4 per cent.

(B.)—Sodium Chloride and Hydrochloric Acid.

The conductivities of the following series of mixtures of hydrochloric acid and sodium chloride solutions were measured:

CONSTITUENT SOLUTIONS CONCENTRATION: GRAMME-MOLECULES PER LITRE.		CONDUCTIVITY OF MIXTURE, $\times 10^8$.
Na Cl.	H Cl.	
2.02	4.55	4932
"	3.89	4492
"	3.29	4089
"	3.19	4073
"	3.06	3958
"	2.66	3623
"	2.56	3489
"	2.34	3323
1.04	4.55	5069
"	3.97	4682
"	3.80	4315
"	3.10	3989
"	2.86	3696
"	2.18	3112
"	2.11	3025
"	1.93	2824
"	1.58	2427
"	1.15	1928
0.607	1.120	1813
"	0.970	1620
"	0.815	1412
"	0.730	1296.5
"	0 603	1114
"	0.485	952

The following table contains in columns 1 and 2 the concentrations of the solutions of hydrochloric acid and sodium chloride which were mixed, and in column 7 the measured conductivities of the mixtures, obtained by graphical interpolation from the above observations. The 3rd, 4th and 5th columns give the common concentration of ions and the respective dilutions of the electrolytes, in the mixture, as determined by Prof. MacGregor's graphical process. The 6th column gives the calculated values of the conductivity, and the 8th the excesses of the calculated over the observed values expressed as percentages.

Constituent Solutions. Concentration (Gramme-molecules per litre.)		Concentration of Ions in the Mixture.	Dilution in the Mixture.		Conductivity of Mixture, $\times 10^8$.		Differences per cent.
H Cl.	Na Cl.		H Cl.	Na Cl.	Calculated.	Measured.	
2	2.02	1.272	.539	.451	3020	3008	+0.4
2.5	"	1.392	.592	.398	3489.5	3456	+1.0
3.0	"	1.485	.636	.354	3885	3888	-0.08
3.5	"	1.570	.668	.322	4233.5	4260	-0.6
4.0	"	1.665	.700	.290	4622.3	4580	+1.0
4.5	"	1.740	.726	.264	4944	4880	+1.3
1	1.04	.744	1.031	.892	1751	1752	-0.005
1.5	"	.916	1.215	.708	2373	2332	+1.7
2.0	"	1.062	1.345	.578	2928.3	2900	+0.9
2.5	"	1.196	1.431	.492	3428.5	3398	+0.9
3.0	"	1.324	1.495	.428	3906	3872	+0.9
3.5	"	1.440	1.545	.378	4340.7	4316	+0.6
4.0	"	1.538	1.585	.338	4715	4700	+0.3
4.5	"	1.628	1.616	.307	5055	5036	+0.4
.4	.607	.392	1.450	1.844	829.8	838	-1.0
.5	"	.436	1.636	1.656	983.4	976	+0.8
.6	"	.474	1.794	1.500	1125.5	1116	+0.8
.7	"	.508	1.922	1.372	1255.	1250	+0.4
.8	"	.544	2.022	1.272	1384.7	1388	-0.2
.9	"	.582	2.121	1.173	1524.6	1525	-0.025
1.0	"	.620	2.195	1.099	1658.6	1656	+0.16
1.1	"	.655	2.267	1.027	1787.6	1784	+0.2
1.2	"	.692	2.322	.972	1917.1	1913	+0.2

It will be seen that in the series of weakest solutions, the differences between calculated and observed values are of such

small magnitude and shew such alternation of sign as to warrant the conclusion that they are due chiefly to accidental errors. In the two series of stronger solutions the differences are more irregular in magnitude and the alternation of sign is much less marked, the most of the differences being positive. The above results, therefore, seem to shew that even in the case of two electrolytes with a common ion, which differ so markedly in ionic velocity from one another as sodium chloride and hydrochloric acid, the dissociation theory enables us to calculate the conductivity of solutions containing both, within the limits of experimental error, up to a mean concentration of about 1 gramme-molecule per litre, and that in the case of solutions of greater mean concentration, the calculated value is greater than the observed.

III.—The Undeveloped Coal Fields of Nova Scotia.—By E. Gilpin, Jr., LL. D., F. R. S. C., Inspector of Mines.

(Read 10th February, 1896.)

The question of the possible discovery of new coal fields in this province is interesting from both a scientific and a practical standpoint. At present the growth of our coal industry is measured by the home demand. The Maritime Provinces take an amount which is steadily, if not rapidly, increasing, as new manufactures are started and firewood becomes scarcer. The Newfoundland demand will not, so far as can be seen, increase rapidly, and moreover, competition is threatened by the island deposits. The trade of the St. Lawrence appears at present practically secured to Nova Scotia, and will grow proportionately to the development of that important section of the Dominion. Ottawa and Montreal appear to mark the western limit of the trade. The inauguration of any policy by which our coals can be pushed further westward against the competition of United States coals rests with the deepening of the canals and the assistance of the Federal Government.

If an outlet be obtained in the New England States the development would grow apace.

We have the subject presented from a practical standpoint. What are the possible reserves beyond those deposits now being worked? While the present mines can be extended in the worked and adjoining seams to meet a demand many times larger than the present, the enquiry is still pertinent. If there is an assurance that outside of the present development there are other tracts that may be drawn upon when needed, the confidence and credit of the province are increased. The assurance of unlimited supplies of fuel, even though we sigh now for larger markets, advertises us abroad and encourages capital to examine our resources of other minerals, and generally to consider more favorably our aspirations for investments of capital.

The *Journal News* has recently published a summary of explorations carried on last year by the Cumberland Railway & Coal Company in the measures underlying the seams at present worked by them. It has always been known that there were underlying seams, but details as to their size were not available. The company has now shown that there are a number of workable seams of good quality available at any time, as shown by the following section in descending order from West slope seam :

	Feet.	Inches.
Seam	3	4
Strata	—	—
Seam	4	3
Strata	—	—
Seam	5	6
Strata	—	—
Seam	2	8
Strata	—	—
Seam	1	6
Strata	—	—
Seam	7	6
Strata	—	—
Seam	2	0
Strata	—	—
Seam	4	8
Strata	—	—
Seam	5	0
Strata	—	—
Seam	7	0
Strata	—	—
Seam	2	4
Strata	—	—
Seam	—	—

This is a case exactly in the line of this argument. The value of the property of this company was before a defined item ; they had large tracts of coal opened by their slopes, ensuring, as far as the coal miner could judge, many years of work. The dis-

covery, however, of these seams, even if they are not likely to be worked for some years, has been a distinct advertisement for that district, and encourages the confidence the local business men and the province feel in the permanency and future extension of the trade of Cumberland County.

I do not pretend this evening to have the wand of Fortunatus, and to disclose to you vast fields of unworked coal, but briefly to refer to districts which may be found upon examination to hold coal of economic value.

The student of geology is most appreciated when he can show the public some material advantage accruing from his investigation, and his predictions are often correct and useful even when they are unpalatable.

I need not refer here to those sections in the province in which coal is now being regularly worked, but proceed to notice briefly the geological conditions which, so far as our experience goes, govern the presence of coal in Nova Scotia.

The term carboniferous is applied by geologists to a group of palæozoic strata, which, while distinguished by holding the best deposits of coal, are also possessed of certain other notable characteristics.

Sir William Dawson stands out as the special delineator of the divisions of this system in the Maritime Provinces. He divided it into :—

Upper Coal Measures,
Productive Coal Measures,
Millstone Grit,
Limestone Series,
Lower or Basal Measure.

And these sub-divisions have been in a general way followed by other geologists.

In this province the limestone series has not presented any workable deposits of coal. It is, as you know, distinguished as an important source of limestone for fluxes, etc., as well as furnishing enormous deposits of gypsum. It is also valued by the

miner as containing ores of iron, manganese, barytes, as well as scattered indications of copper and lead ores. In this connection, however, it need not be referred to in greater detail. The same may be said of the Lower or Basal series. This is composed largely of conglomerates and coarse Grits which often rest on Silurian or Laurentian strata, in some cases holding contact deposits of iron ore or manganese. At several points, however, in the province, the conditions of deposition permitted the accumulation of more finely comminuted strata, and we have beds of shales, often bituminous or carbonaceous. It is noticed at a few points that the accumulation of carbon matter has been large enough to form impure "coal" beds. Prospectors have spent much time and money with unsatisfactory results in these strata, which often surpass the shales of the productive measures in their various carbon contents. In a few cases these coaly beds have been hardened by metamorphic action into graphitic slates or semi-anthracitic beds.

As far as I am aware the Upper Coal measures contain only a few thin but remarkably persistent seams running from Merigomish to River John. This set of strata appears to pass by no fixed line into the lower and preceding productive measures. These again are divided by no arbitrary boundary from the Millstone Grit. Coal seams are not infrequent in the Millstone Grit in Nova Scotia as in other countries. We are therefore, in the study of this subject, concerned in the presence of coal in the Productive and the Millstone Grit measures, and they may be considered together.

In the Sydney coal field the boundary laid down between these systems is based principally on the cessation of thick and abundant coal beds and the presence of seams smaller and not so abundant, as well as on the appearance of strata coarser in texture. Mr. Fletcher of the Geological Survey, however, in continuing his survey of Cape Breton, found that in many places nature did not present coal seams and differing strata conveniently for this purpose, and has grouped the two together. The question need not be gone into here as to the true horizon of some of our coal

deposits, as we are now practically concerned about the size, etc., of coal beds, not about their scientific age.

Leaving the consideration of the productive measures of the Sydney coal field out of the question, and adopting the boundary there laid down by the Geological Survey between the two sets of measures, it may be taken as a fact that in the Millstone Grit in that district there do exist workable seams of coal of which I may mention the Mullins, Gardner, Long Beach and Tracey seams. It is plain, therefore, that even if exception may be raised to the productive age of the rocks holding coal seams elsewhere, we are starting with the important premises that the Millstone Grit does hold valuable coal seams in the Sydney district, and that in other districts explorations may show deposits of equal value. The following condensed sections will show what is so far known of the coal contents of this horizon in the Sydney district:—

In Cape Breton County there extends from the rear of Lingan Bay and Glace Bay to Mira, and thence up the river of that name and its branch, the Salmon River, as far as Loch Lomond on the county line, a large area of Millstone Grit. Seams of coal are known throughout this district. Classing the Mullins, Gardner and Tracey seams in this horizon the fact is established that it presents seams of workable size lying, geologically speaking, thousands of feet below the seams classed as the lowest of the true or productive measures, as shown by the following condensed section:—

In the section showing from the south head of Cow Bay to the head of Mira Bay there are, in about 1,900 feet of strata, eleven seams of coal, the thickest, the Tracey, being 4 feet. Four of them have a workable thickness.

In the centre of the district, assuming with the Geological Survey that the summit of the Millstone Grit begins a short distance above the Lorway or Gardner Seam, we have first that seam 5 feet 9 inches thick, then in about 700 feet of measures there are six coal seams varying in thickness up to two feet.

In the section underlying the productive measures at Low Point, at a vertical distance of 600 feet below the top of the Millstone Grit, is the Mullins seam, 6 feet 4 inches thick. Several other smaller seams unknown in this section of which I have no details.

On the North Sydney side of the harbor the Geological Survey give only one seam about 580 feet below the top of the Millstone Grit, the Matheson seam, 2 feet thick. It is claimed by those who have since prospected this district that there are several other seams up to 5 feet in thickness.

On the Big Bras d'Or the sections of the Millstone Grit have hitherto shown only traces of coal.

For a few years past attempts have been made to trace the Mullins seam southwardly into the extensive district lying between Sydney and Glace Bay, and to prove the Tracey seam northwardly into the same district. These efforts have not yet proved successful. There are a number of seams known in this area, as shown in the section, none, however, large enough to compete with those at present worked, although they will be drawn upon in the future when the larger seams become exhausted, and they contain in the aggregate many millions of tons of coal.

On the Morrison road explorations have been carried on by Mr. Harold and other Sydney parties. They claim to have bored through a number of workable seams. The details of this exploration, not yet completed, will be received with interest, as if their claims as to the thickness of the seams are supported by a good quality of coal a most important addition will be made to the coal resources of the district.

An interesting portion of this coal field was described by me in a paper read before you last winter, as the results of some of the prospecting for the Tracey seam. Attention was drawn to the curious fact that the fossils of the Cossitt coal field were identical with many characteristics of the true coal measures, although the locality lies in the heart of a wide expanse of Millstone Grit.

Southerly of this lies the Mira district; here there are a few known outcrops of small seams, but little tested except at some natural exposures. The country is swampy with numerous lakes and moss grown, and the natural exposures are principally of the harder ridges of sandstone or grit. In the Salmon River district there are three well marked seams of coal from 12 to 36 inches in thickness, lying in the valley between the East Bay and Mira felsites, etc.

The work showed the existence of a long narrow trough holding the outcrops of several seams under two feet in thickness.

The first of these on the Gaspereau River road is stated to be eighteen inches thick, to burn well and to yield little ash. A second outcrop similar in character occurs between the Glengarry and Ardoise roads on the shore of a small lake. The third and most important exposure is on the Salmon River, two miles south of the Morrison road, where two eighteen inch seams are met divided by a band of fire-clay. The coal burns readily, but from the following analysis contains an unprofitable amount of ash:—

Moisture	1.53
Volatile Combustible Matter	20.16
Fixed Carbon	47.49
Ash	30.82

It was stated some time ago that explorations had shown larger and more promising outcrops in this district. The prospectors have taken out a number of leases and as they are willing to pay the annual rental on them it must be presumed that they are satisfied with their prospects.

In the district lying to the westward of the General Mining Association's lease at Sydney Mines, and extending from Sydney Harbor to the Big Bras d'Or, there are a number of outcrops of seams. Local authorities, as already stated, claim to have identified them with the lower seams on the Victoria Mines shore of the harbor, and that they are in some instances increased in size.

As yet, however, this district has not as a whole been systematically tested, and indications are not wanting that the conditions, favorable to the formation of coal beds in the Millstone Grit, decreased with proximity to the syenitic rocks of St. Ann's.

The Millstone Grit of the Sydney district appears to attain its maximum thickness in the Mira Bay section, and according to Messrs. Fletcher and Robb, it decreases until at its northern extremity in the Cape Dauphin district it has diminished from over 5000 feet to less than 2000 feet. Being derived from the detritus of the underlying strata it is reasonably noticed that as it approaches the older and harder pre-carboniferous rocks it becomes scanter and coarser. This change necessarily diminishing the opportunity for the presence of those conditions permitting the accumulation of carbonaceous matter.

Passing to Richmond County there is found a long stretch of the debateable Productive Millstone Grit measures running from near St. Peter's across the lower part of the Inhabitants River nearly to Hawkesbury.

Coal seams of economic value are known at Coal Brook, Little River and Carabacou Cove. At the first named place explorations have shown a three feet, a four feet, and several smaller seams of coal. The quality is stated to be good as far as the crop workings were extended. At Carabacou Cove, or, as it is also called Sea Coal Bay, quite extensive workings were carried on about thirty years ago in a seam eleven feet eight inches thick, holding some layers of shale. Reports made to the Government of Nova Scotia state that there are in this connection at least seven other seams ranging in thickness from three feet upwards, beside a number of smaller ones. The Big Seam was reported by Sir William Dawson to carry an abnormally large amount of ash, as shown by the following analysis :—

Volatile Matter	25.2
Fixed Carbon	44.7
Ash	30.1
	100.0

Owing to the want of demand for coal and to the heavy surface cover accompanied by the almost vertical position of the seams, little progress has been made in tracing the seams inland towards Hawkesbury. It is probable that they are sharply folded at no great distance from the shore, and their nearest outcrop at Little River represents their re-appearance on a parallel folding.

At Little River the measures are steeply inclined and present the following section ascertained by the Eastern Development Company some years ago :—

	Feet.	Inches.
Coal	3	0
Strata	154	0
Coal	4	0
Strata	60	0
Coal	3	0
Strata	45	0
Coal	5	0

The upper beds were opened and a few hundred tons extracted. The coal is compact and apparently of good quality. The upper part of the section appears to agree with that of Sea Coal Bay.

The following analysis given by Sir William Dawson in a report made by him many years ago, will show that the large percentage of ash forms the principal drawback to the fuel :—

Volatile Matter	30.25
Fixed Carbon	56.40
Ash	13.35
	100.00

I am informed that the workings of the Eastern Development Company a few years ago showed a decided improvement in the quality of the coal away from the outcrop. Attempts made to follow these seams have not proved successful, probably because they are here as at Sea Coal Bay folded in sharp curves, and the surface is level and deeply covered with detritus. The construction of a railway from Hawkesbury to St. Peter's and Louisburg, recently subsidised by the Provincial Government, across this

coal field will undoubtedly lead to a fresh interest being taken in this important but hitherto almost unknown coal field, so favorably situated for marine shipments all the year round.

During the early days when the almost complete abandonment of the exclusive rights of the General Mining Association threw open the provincial coal areas to the public, a great deal of desultory prospecting was done in this district. It is to be regretted that the results of this work have been lost, if indeed they were ever recorded. Mr. Fletcher, after compiling all available information, has been able to present only a comparative statement of its structure.

This district differs from that already described in that there appears to be a relationship between the gypsum and the coal beds not yet clearly explained.

At Glendale, on the upper waters of the River Inhabitants, there is a small fairly well defined coal field, a few square miles in extent, showing, from recent explorations, a three feet and a smaller seam. Great part of the Inhabitants district is swampy and overgrown with spruce and alder thickets. The strata in many places are soft, worn down, and covered with heavy local detritus. For these reasons little progress has been made in tracing the structure, and beyond the known outcrops it will be necessary to resort to the expensive process of systematic and deep borings. So far, however, it may be fairly assumed of this coal field that there must undoubtedly be a large amount of coal in it.

At Mabou there are two small patches of coal measures, separated by half a mile of lower strata, evidently at one time connected. They contain in the more southerly basin four seams given by Mr. R. Brown in his "Coal Fields of Cape Breton," as follows :—

	Feet.	Inches.
First Seam....................	5	0
Second Seam..................	7	0
Third "	13	0
Fourth "	4	0

included in about 550 feet.

As these strata have an inland range of only a few hundred yards and dip under the sea, their value is by no means commensurate with the richness of the section. It is important, however, to note that such favorable conditions existed on this side of the island for the accumulation of coal seams.

The Port Hood district may next be referred to. Here openings have been made on an excellent seam, which, outcropping on the shore, dips under Port Hood Harbour. In the rear of this seam there is an area of about ten square miles which merits examination. Coal seams of small size are reported about a mile from the shore at Port Hood, and indications of coal for nearly two miles further east.

The following section shows the relative positions of the seams as given by Mr. Brown :—

	Feet.	Inches.		Feet.	Inches.
Coal at tide water				6	0
Strata				360	0
Coal	1	0			
Coal Slate	0	9	Seam worked	6	0
Coal	4	3			
Strata containing several thin seams				1500	0

Should coal seams be found in the as yet unexplored district back from the shore they will presumably extend not only under the land area but also conjointly with the known seams under the harbor.

The islands forming Port Hood Harbor are partly underlaid by coal measures. It has been assumed that a shaft sunk on them would open up a large coal field. While the measures are the same on the islands as on the mainland, the faults on them bringing up the limestone and gypsum would render the assumption of absolute continuity a matter of discussion. The question of their value to the coal miner could be settled only by boring.

At Broad Cove work has been done to show that in the land area there are a number of valuable coal seams, which will also be available under the water. The area of this coal field appears

to be limited on the south by the syenite of Cape Mabou on which it rests without the intervention of any of the lower groups of the carboniferous. Its inland extension at other points appears to be limited distinctly by the belt of limestone and gypsum which sweeps from the shore north of the mouth of the Broad Cove Brook nearly to the Mabou Hills. Here there is an interval of metamorphic lower carboniferous rock probably valueless to the coal miner. The coal field on land is about six miles long and about two miles across at its greatest width.

The sections of the seams as given me during the past few years do not agree with those hitherto published, or with one measured by me some years ago.

Mr. W. H. Ross, who has been engaged by the Broad Cove Coal Company in opening the seams and in making a shipping harbor at McIsaac's Pond, an inlet on the centre of this coal field, has kindly agreed to give the Institute a full description of this district. I will therefore not attempt to correlate the sections, but for the purpose of rounding out these notes will give the following sections from Mr. Robb's report to the Canadian Geological Survey :— In descending order,

	Feet.	Inches.
Seam No. 1....................	3	0
" 2....................	5	0
" 3....................	7	0
" 4....................	4	6
" 5....................	3	0
" 6....................	3	9

An idea of the importance of the western shore of Cape Breton as a future coal producer may be formed from Mr. Robb's estimate that these seams contain on land not less than 26,000,000 tons in the land area and 34,000,000 in the sea area to a distance of only half a mile from the shore. As there is also, in addition to the seams named, a fourteen feet seam of coal, these estimates should be largely exceeded, and the sea area of available coal held by parties other than those named by him also hold large amounts of coal.

Continuing to the north, the Margaree, or as it is more commonly known the "Chimney Corner" district, is next met. Here the shore from Marsh Point to Margaree Harbor is occupied by coal measures, indicated as being made up of Productive and Millstone Grit rocks. The length of this field on land is about twelve miles and its width about 2½ miles. At Chimney Corner workable seams of excellent quality have been opened and mined to a small extent. At the mine these beds are close to the water and could presumably be followed under it. Little or no mining and exploratory work has been done at Chimney Corner for a number of years. The following section is from a report by Professor Hind:—

	Feet.	Inches.
Thin Seam	1	6
Strata	300	0
Coal	3	0
Strata	88	0
Coal	5	0
Strata	200	0
Coal	3	6

The seams have been traced to the south about four miles, and are stated to be larger and of equally good quality. The section of country lying back of these seams has yet, so far as I am aware, never been examined for coal. It is stated that a few outcrops of thin seams and of a three feet seam have been found about two miles from the shore. The reasons for this indifference as to the possible coal values of this district are not far to seek. The isolation of the locality and the absence of shipping facilities are evident. If, however, at any time shipments were decided on, no difficulty would be experienced in making a harbor at Chimney Corner, or in dredging the entrance to Margaree Harbor. A lagoon harbor is now being made at McIsaac's Pond, at Broad Cove, and the establishment of the same style of harbor at Margaree would be attended with less difficulty as the volume of the Margaree River is sufficient to secure a considerable scouring action.

It may be mentioned that Seat Wolf Island lying a short distance off the shore at Chimney Corner is composed of measures the same as those on the mainland, and this fact contributes to the permanence of any subaqueous extension of the coal seams. From Margaree to the northern end of Cheticamp Island there is a narrow fringe of coal measures. I am not in possession of any information as to the indications of the presence of coal in the Cheticamp district.

No point in the interior of the island presents coal measures, and it has been carefully examined by Mr. Fletcher. The two systems occurring there are the felsites, syenites, limestones, etc., of the Laurentian and the basal conglomerates, limestones, gypsums and associated beds of the lower part of the carboniferous.

Reports of discoveries of coal are not infrequently made from localities outside of those I have referred to, but so far as our geological information goes they are not likely to prove of value, and the test of exploration has invariably sustained this view. At St. Lawrence Bay the coal seam is a black bituminous shale holding patches of coaly matter and associated with limestone and gypsum.

At Hunter's Mountain and Ingonish irregular and impure layers of coaly matter occur in the Lower Carboniferous. On the Mabou River, East Bay, and a number of other places work has been done on carbonaceous shales, which often carry sufficient carbon to burn and give heat enough to raise steam and to be used for domestic purposes. The percentage of ash, however, is a fatal barrier to their competition with imported Anthracite coal. These beds may present greater value as sources for the manufacture of oils, etc.

Beds of graphitic shale or slate are frequently taken to indicate the vicinity of coal, or are tested with faith in the mining axiom that every mineral becomes richer the deeper it goes.

Other discoveries of coal resolve themselves into beds of black fire clay or shale carrying streaks of coaly matter, or into limited masses of coal due to some small accumulation of plant remains, and consolidated into a more or less bituminous coal, often holding a high percentage of ash.

The following analyses will show the character of these "coals:"—

	I	II
Volatile Combustible Matter......	17.80	36.72
Fixed Carbon....................	29.04	46.64
Ash....	53.16	16.64

At present, of course, the interest of the prospector in the unexplored portions of the coal fields of Cape Breton lies in the hope of discovering seams which will compete in size with those now being worked. All things being considered a seam of coal about six feet thick can be worked as economically as a larger one and more cheaply than a smaller one. As this paper is written with as much reference to the future as to the present status of the coal industry, it is fair to remember that coal seams with a much less thickness than six feet often acquire more than a local value. From the recently published report of the investigation of the British Iron Trade Association into the conditions affecting the iron industries of Belgium and Germany, a reference can be given directly bearing on this point. The official reports of the Belgian Government show that the average depth of the Belgian coal pits was 1,400 feet, and the average thickness of the worked seam was 2.08 feet.

In Germany, the same report states, the official returns show the average thickness of the worked seams to be 3.28 feet. It is plain from these figures that in these countries a large number of very thin seams must be worked to give so low an average thickness. Connected with this point the figures given by the report as to the cost of the coal at the pit head in these countries is interesting. The cost is in Belgian about $1.75, in Germany about $1.60, and in England about $1.45 per ton.

The discovery therefore in the areas referred to of seams of coal, even though they be smaller than those at present worked, is of value, as locating future reserves of fuel. The work so far done has proved that very large areas in these districts present seams at present available to the coal miner so far as their size

and quality is concerned; and there appears to be good ground for believing that these seams may be found to extend over considerably larger areas than at present proved, that other seams equally good may be discovered, and that numerous smaller seams which will prove valuable in the future are present, and that others will probably be found.

IV.—NOTES ON THE GEOLOGY OF NEWFOUNDLAND.—BY T. C. WESTON, F. G. S. A., LATE OF THE GEOLOGICAL SURVEY OF CANADA.

(Read 11th May, 1896.)

The following notes have been written partly to record a few palæontological facts not mentioned elsewhere and partly to give a brief outline of the various geological formations and show the similiarity in the fossil faunas of Newfoundland to the members of the upper and lower silurian of Canada. Should the reader wish for a more detailed account of the geology, he will find it in the admirable reports of the late director of the Geological Survey of Newfoundland, Alex. Murray, also in those of his assistant, Jas. P. Howley, and of the late Sir W. E. Logan, Geological Survey of Canada, 1863.

The Laurentian.—In considering the more interesting geological features of the island, we shall commence with the base of the great geological column, which in Canada has an estimated thickness of 32,750 feet.

The Laurentian rocks of Newfoundland are similar to those of Canada, consisting of gneiss, granite, syenite, limestone, quartzite, mica schist, etc., all of which are frequently cut by granite and other dykes. They form a large portion of the island which, as Mr. Murray remarks, " has materially contributed to produce the remarkable geological aud topographical features which it presents." Probably it was the chopped up appearance of the Laurentian and Huronian formations which caused him to remark that " Newfoundland was formed of the chippings of the world." The Laurentian of Newfoundland, so far as we know, is totally destitute of the remains of either vegetable or animal structure, and therefore must still be considered azoic, although this term has been abandoned by some geologists in the nomenclature of Canadian rocks owing to the discovery in the Upper

Laurentian of certain forms which resemble *Stromatocerium rugosum*, one of the Protozoa of the Silurian. This peculiar mineral aggregate (?), received from Sir W. E. Logan and J. W. Dawson the name *Eozoon Canadense.* Literature enough to fill a cart has been published for and against this supposed organism, among which Dawson's Dawn of Life is the most interesting. With the exception of Sir J. W. Dawson, probably no one has done more work at this supposed fossil than the writer, who has prepared hundreds of microscopic sections, micro-photographs, micro-drawings, illustrative collections for the Paris, London, Philadelphia and late Chicago Expositions, and for other public and private collections; still he could never make up his mind that *Eozoon Canadense* is of organic origin. Mr. Billings, late palæontologist to the Geological Survey of Canada, pronounced strongly against the organic character of *Eozoon.* I have frequently conversed with Dr. Selwyn, Mr. Whiteaves, Dr. Ami, Dr. Ells, the late Mr. Vennor (who obtained the Tudor specimens), and other members of the Canadian Survey, but none of these gentlemen ever admitted that Eozoon is a fossil. However Eozoon will always remain an interesting subject for students in palæontology and mineralogy.

The Huronian.—In Canada the Huronian system represents a thickness of about 20,000 feet of strata consisting of quartzites, slates, limestones, sandstones, chert, jasper, conglomerates and other rocks in which no fossils have been found. While important measures represented in Canada are missing in Newfoundland, there is a great similiarity between the Huronian of the two countries. Its exact thickness in Newfoundland does not appear to be known. Murray gives a section of 11,370 feet of strata consisting of diorites, quartzites, jaspers, slates, conglomerates, sandstones, etc. Like our Canadian Huronian, these rocks in Newfoundland have yielded no fossils unless we consider Billings' *Aspidella terranovica*, and two other obscure forms mentioned by the same writer as organic.

In his report for 1868 Mr. Murray speaks of these forms described by Billings—Palæozoic Fossils, Vol. II, Part I., and also

refers to other forms found in Huronian argillite by the Rev. Mr. Harvey. At the time of the discovery of these fossil-like markings they were considered to be most important, and were supposed to belong to the genus *Oldhamia*, and specimens were sent to Sir W. E. Logan. Billings would not decide one way or the other as to their organic affinity, and they were handed to me. I said at once they were concretionary, and, what had not been observed by others, that these markings lay transverse to the bedding of the slate in which they were.*

Billings describes his *Aspidella terranovica* thus: "Small ovate fossils five or six lines in length, and about one-fourth less in width. They have a narrow ring-like border within which there is a concave space all round. In the middle there is a longitudinal roof-like ridge, from which radiates a number of grooves to the border. The general aspect is that of a small *Chiton* or *Patella*, flattened by pressure. It is not probable, however, they are allied to either of these genera."

While in the City of St. Johns in 1874, I made a diligent search for these forms and collected several of the so-called *Aspidella*. These, together with all other specimens now in the Dominion Geological museum, vary so much in form and appearance that I am afraid they also will ultimately be classed with the concretionary forms already spoken of, collected by the Rev. Mr. Harvey. Thus it will be seen that we have no definite organic remains either in the Laurentian or Huronian rocks of Canada or Newfoundland.

The Primordial Silurian of Newfoundland and Canada. —In spite of the oft-repeated assertion of Professor Jukes and the late director of the Geological Survey of Canada,—"If the fossils don't agree with the stratigraphy, so much the worse for the fossils," my long experience as a collector of fossils and close observer of the various geologic horizons leads me to think that if the stratigraphy does not agree with the fossils so much the worse for the stratigraphy. To illustrate the faith the late

*Notes by the writer, and a reproduction from a nature print in Trans. Nova Scotian Inst. of Science, Second Series, Vol. I, Part 2, page 139.

director of the Newfoundland Survey had in palæontological evidence, I will relate one incident out of many similar ones known to the writer:—In the summer of 1874 Murray wrote to Sir W. E. Logan, then director of the Canadian Survey, saying: "I have made my Manuel's River rocks Primordial; I am doubtful, however, whether my stratigraphy is correct; neither Howley nor I have been able to find the ghost of a fossil; could you arrange in any way to send Weston down for a few weeks." The result was that I left by the next steamer which called at Newfoundland, and a few days after my arrival at St. John's was sent by Murray to Manuel's River where he got lodgings for myself and indian guide. The following day I commenced my search for fossils, and in a short time was rewarded by finding, in the gray argillites, the well-known crustacean *Microdiscus Dawsoni*, Hartt, which occurs in abundance in the primordial slates of St. John, at Ratcliffe's Mill Stream, and other localities in New Brunswick. This crustacean, *Microdiscus*, is a puny thing, not larger than the half of a small pea, but it told me a big tale about the geological horizon—told me that Murray's stratigraphy was correct, and that I stood on primordial strata similar to those of St. John, New Brunswick.

I may mention here that the term primordial, used by Barrande and the late palæontologist of the Canadian Survey, Mr. E. Billings, is seldom used now—St. John Group being thought a better name for that extensive group of rocks. This Cambrian division of the lower silurian of Newfoundland according to Murray would, if found consecutive at any one locality, represent a thickness of 6,000 feet of black, gray and other coloured argillites, micaceous calcareous slates and limestones, sandstones, conglomerates and other rocks, some of which are prolific in fossils, especially the iron-stained argillites of Manuel's River and other localities in Conception Bay. The fauna is similar to that of the primordial of St. John, Ratcliffe's Mill Stream, and other localities in New Brunswick.

Among the forty or more genera and species of this group in Newfoundland Billings describes about sixteen species, some of

which are now placed in the next zone—Middle Cambrian. I mention here only a few of the most typical forms:

Eophyton linnœanum, Torrell.
Cruziana similis, Billings.
Lingula Murrayi, Bill.
Hyolithes excellens, Bill.
Senella reticulata, Bill.
Stenotheca pauper, Bill.
Microdiscus Dawsoni, Hartt.
Paradoxides tenellus, Bill.

The Upper Potsdam as represented in Canada and parts of the United States does not appear in Newfoundland.

Calciferous.—The calciferous group which in Canada forms a prominent feature, having a thickness of 300 feet and a large fossil fauna, does not appear to be defined in Newfoundland, although it is said to be represented there by a thickness of 1,000 feet, and another set of strata over 200 feet thick which may belong to the upper calciferous zone.

This great thickness of rock does not appear to have yielded any typical calciferous fossils. From my personal observations I am inclined to think that a great portion of it belongs to the series known as "The Quebec Group," of which I shall now say a few words:

The Quebec Group.—This great metalliferous group which forms an important feature in our Canadian geology is largely developed in Newfoundland and is characterized by the same varieties of rock, among which are various coloured limestones, black, gray, green, red, and other shales and slates, conglomerates, serpentines, etc., forming a thickness of over 5,000 feet. It is in Newfoundland, as in Canada, the great mineral-bearing belt of rocks, in which silver, copper, lead, iron, manganese, plumbago, gypsum, marble, petroleum, etc., have been found.

It was recognized by the finding of typical Levis fossils —Graptolites—which are peculiar to this zone of the Quebec group of Canada.

It is probable, however, that a portion of the rocks now classed as Quebec group in Newfoundland belong to a higher zone. A glance at some of the fossils from these limestones (which may be seen in the museum of the Geological Survey of Canada) especially silicified forms which have been exposed by dissolving the matrix with acids, will show the resemblance between them and our Canadian Black River and Trenton forms which is remarkable.

The following are a few of the more interesting fossils collected in various localities in Newfoundland, by Murray, Richardson, and Weston :

PROTOZA,—

Trachyum rugosum, Bill.
" *cyathiforme,* Bill.
Stromatocerium rugosum, Hall.
Calothium affine, Bill.
" *filloni,* Bill.

HYDROZOA,—

Callograptus elegans, Hall.
Tetragraptus (Graptolithus) *fruticosus,* Hall.
" *bryonoides,* Hall.

BRACHIOPODA,—

Lingula irrene, Billings.
" *Murrayi,* Billings.

GASTEROPODA,—

Pleurotomaria numera, Billings.
Murchisonia simulatrix, Billings.
Maclurea crenulata, Billings.
" *emmonsi,* Billings.

CEPHALOPODA,—

Orthoceras piscator, Billings.
" *servile,* Billings.
Nautilus calciferus, Billings.

CRUSTACEA,—

Bathyurus timon, Billings.
Asaphus morosi, Billings.
Illænus arcuatus, Billings.
Agnostus fabius, Billings.

For other fossils of the Quebec group from Newfoundland, see Billings' Palæozoic fossils.

In this short description it would take too much space to record information obtained of other members of the upper and lower silurian. Some of these are not represented as in Canada, while others probably never will be well defined owing to the absence of, or a poor state of preservation of the fossils, which consist chiefly of corals, stems of encrinites, and other forms which are not typical of any formation between the Trenton and Devonian. I shall therefore conclude with a few remarks on the Devonian, Carboniferous and Superficial formations.

The Devonian.—This formation in Newfoundland is supposed to be equivalent to a portion of the Gaspé sandstones of Canada, which at Gaspé, according to one of Logan's sections, has a thickness of 7,036 feet, consisting of sandstones, shales, limestones, conglomerates, etc. It is not well defined but some of the fossils which characterize the Gaspé sandstones at Gaspé have been found also in Newfoundland, among which are *Psilophyton*, *Lepidodendron*, *Sigillaria*, *Sphenopteris*. The Gaspé series contains a large fossil fauna and is important owing to its petroleum springs and other minerals.

Carboniferous formation.—Murray states that the carboniferous of Newfoundland is clearly an extension of the rocks which constitute the coal-fields of Cape Breton and Nova Scotia. The formation consists of conglomerates, shales, limestones, sandstones and interbedded coal seams. Jukes, in his geology of Newfoundland, speaks of a seam of coal 6 inches thick on the Coal Brook. Other thicker workable seams have of late years been reported. A description of the coal mining district by Dr. Gilpin is to be found in the transactions of this Society (Trans. N. S. Inst. of Sc., Vol. III, page 357.)

The limestones of this formation are often prolific in fossil shells; one of these bands is 26 feet thick, and is composed chiefly of a species of *Terebratula*; others hold *Stigmaria* rootlets, *Sigillaria* and beautifully preserved ferns. The carboniferous rocks of Nova Scotia are more than 14,570 feet in thickness. One of the bands of conglomerate is 1,400 feet thick. The carboniferous formation is probably the most important group of rocks in the 28 miles of strata which once formed, what we only have a portion of now, the crust of the earth.

Superficial Deposits.—The superficial deposits of Newfoundland are represented by stratified clays containing modern shells. Some of these clays are from 50 to 60 feet thick. Erratic boulders fill many of the valleys and cover large portions of the island.

Ottawa, April, 1895.

V.—GLACIAL SUCCESSION IN CENTRAL LUNENBURG.—BY W. H. PREST, *Chester Basin, N. S.*

(Read 11th May, 1896.)

While prospecting for gold bearing veins during the past two years, my attention was called to the opportunities thus given to study the glacial geology of the district worked in. The following observations and deductions are chiefly the results of work done in the district between Bridgewater and Mahone Bay, during parts of the years 1895 and 1896. My study of this district is not in any way thorough, but consists merely of occasional observations and their resulting conclusions. Knowing the great difficulty of correlating distinct and distant deposits, I approach the subject with trepidation, but, notwithstanding, trust that the facts given may be of some service to future investigators.

PHYSICAL FEATURES.

The general physical features of this part of Nova Scotia are those of a gradual slope from the central watershed to the Atlantic coast. This watershed, the South Mountain, averages probably 700 feet in height, and is about 45 miles from the Atlantic, which gives the very gentle descent of 1 foot in 340. Its surface is diversified by morrainic accumulations which reach a considerable development near the coast at Lunenburg. The more local features are those of a low table-land, bounded on the south-west by the valley of the Lahave, on the north-east by the Mush-a-mush valley and Mahone Bay, and on the south-east by the Atlantic Ocean. Its northern end is a continuation of the higher land of the interior. In the central parts of this table-land are the shallow subsidiary basins of Rhodenizer's and Cantiloup's Lakes. At Blockhouse, in the eastern part of this area, the surface is undulated by morraines and intervening swamps and valleys. Here in a shallow valley, running about S. 50° E., a large part of my work was done, and observations made. The

height above the sea level is probably about 135 feet. The Lahave occupies a narrow pre-glacial valley, reaching 20 to 30 feet below high tide, and flowing amid picturesque hills about 200 feet high. The Rhodenizer Lake basin drains the highest part of the table-land and flows S. S. W. between morraines and kames until it reaches the estuary of the Lahave. The central part of this basin, at Blysteinner Lake, is 183 feet above mean tide level, while Rhodenizer's Lake is 160 feet. The Cantiloup Lake basin drains the southern part of the tract under discussion, and is occupied and surrounded by morraines which have in some cases diverted the streams from their pre-glacial courses. At Dorey's Brook, in this basin, work was done which disclosed several facts bearing on the glacial succession in this district. I will now give a few sections which represent fairly the majority of those recorded by me. They are numbered to correspond with the glacial or inter-glacial epoch in which they are supposed to have originated. (See page 164.)

DESCRIPTION OF DEPOSITS.

Blockhouse.—The sections set down below are copied from a record kept on the spot, and taken down as the work of trenching and sinking proceeded. As those pits are sunk quite close to each other, the correlation of the deposits in this locality was not a very difficult matter. The sections of course differ as the position and depth of the pits showing them differed, but the corresponding layers in each section will be numbered alike regardless of their distance from top to bottom. The absence or presence of auriferous quartz in the upper layer was owing to its position in regard to the lead. If on the lead, the lower layer contained the gold-bearing quartz ; but if to the south-east, then the upper layer contained it.

Section 1, beginning at the top, 13 feet deep.

5, Clay and rocks, mostly local and much oxidized.

4, Signs of denudation.

3, Dark coloured boulder clay, including granite, quartzite, and other northern drift.

2, *d*, Signs of denudation.

" *c*, Small stones firmly cemented with bog iron.

" *b*, Soft red gravelly clay, slightly stratified.

" *a*, Fine blue clay with local angular drift and auriferous quartz from lead beneath.

Section 2.—Depth 10½ feet.

7, Unstratified brown rocky soil, of local origin, on edge of meadow, probably disarranged by ice.

6, White clay

5, Brown, rusty, gravelly and sandy clay, with broken slate and quartz, all of local origin.

4, Bright red and yellow ocheous clay.

3, Rusty, red and brown stoney clay, with well worn boulders of granite and quartzite, but no local drift. Polished round and oval pebbles, doubtless from a kame of earlier origin, are included in this bed.

2, Blue clay with slate and auriferous quartz from vein beneath.

Section 3.—Depth 8 feet.

6, Fine dark coloured clay.

5, Well oxidized local drift, consisting of gravel, clay, quartzite and slate.

4, Finely stratified sandy seam.

3, Gravel, clay, and worn boulders, some of them granite, with tough clay near bottom.

Section 4.—Depth 8 feet.

5, Brown, loose, rusty slate, gravel, and auriferous quartz, all of local origin.

4, Four inch seam of angular slate, cemented with bog iron

3, Boulder clay of a more northern origin.

Section 5.—Depth 14 feet.

5, Brown, rusty, and partly cemented drift, of local origin, containing auriferous quartz.

4, Signs of denudation.

3, Clay, with massive boulders of quartzite slate, trap and granite, all well worn. This bed contains polished pebbles of

granite and quartz, no doubt derived by denudation from a kame of earlier age.

2, Blue clay, with broken fragments of local rocks.

Section 6.—Depth 15 feet.

5, Brown, rusty and partly cemented slate and gravel, with auriferous quartz, all of local origin.

4, Signs of denudation.

3, Boulder clay with large boulders of trap, granite, quartzite, and slate, and fine tough clay at the bottom. Contains rounded and smoothly polished crystalline rocks which seem to have been eroded from an earlier deposit.

Dorey's Brook.—Section, 6 feet deep.

5, Local drift, with auriferous quartz, from a vein near by.

4, *d*, Fine tough white clay, without quartz.

" *c*, Fine tough brown clay, without quartz.

" *b*, Fine tough brown clay, with quartz, from above-mentioned vein.

" *a*, Modified boulder clay, with quartz.

3, Boulder clay, granite rare, quartz absent. The above section is about 140 feet above tide level.

Rhodenizer's Lake.—Kame with section at an angle of 45°, about 60 feet deep, and about 180 feet above mean tide level.

3 (?), Surface soil apparently till, 4 feet.

2 *e*, Stratified beds of sand, gravel, clay, and small rounded rocks, 17 feet, 8 inches.

" *d*, Conglomerate of large rounded rocks, many of them granite and trap, 2 feet.

" *c*, Stratified beds, as at 2, *e*, 12 feet, 4 inches.

" *b*, Unstratified or disintegrated bed of sand clay and waterworn rocks, 4 feet.

" *a*, Stratified layers as at 2, *e*, 15 to 20 feet.

1, Drift conglomerate of worn and angular fragments of slate, quartzite, granite, and trap, thoroughly cemented by bog iron.

It shows no sign of stratification, and contains large numbers of striated boulders.

A few boulders with the striations almost effaced are found in 2, *a*, and striated boulders are also found in the surface soil, 3. Oxidization is most complete in the lowest bed, 1, which is of great thickness, while the upper bed is the least oxidized of all. This is only part of a larger kame which has suffered extensive denudation on the western side.

At Bridgewater it is impossible to get a good section, but near the railway station and at Sebastopol the beds show the following arrangement:

7, Recent alluvium, with tree trunks and stumps, and ancient Indian implements, overspread by forest growth.

6, Modified drift and river gravels.

2 to 5, Succession uncertain. Deposit consist of boulder clay, kames, and river terraces; the kames being very highly oxidized and consisting of the same material as the underlying oxidized drift.

1, The so-called Bridgewater conglomerate,—a pasty iron cemented mass of rounded and angular boulders of quartzite, slate, granite, trapand diorite. This is the most highly oxidized deposit in this part of the province, and contains striated rocks. It is slightly modified in its upper portions, but is underlaid by completely oxidized local drift, consisting of angular fragments of slate in a matrix of clay and sand.

CORRELATION OF DEPOSITS.

First Glacial Epoch.

The Bridgewater drift conglomerate is evidently the most ancient glacial deposit in this part of Nova Scotia. The evidence for this is as follows:—

1st. It is always seen in direct contact with the bed rock and cemented thereto, so as to become in its lower portions almost immovable without the aid of dynamite.

2nd. In spite of its extreme hardness, it has been denuded to a greater extent than any other such wide-spread deposit in the region under consideration. The only places where it can now be seen being along the valley of the Lahave, and along the watershed to the east.

3rd. Since its deposition over highland and lowland alike, and in the pre-glacial valley of the Lahave, that river has been re-excavated and the conglomerate left only in a few isolated patches along its banks. And this has taken place before the depositions of lowest kames and boulder clay.

4th. It debris has been formed into kames which are in turn older than the boulder clay that covers them.

5th. It is more intensely oxidized than any other deposit in the southwestern counties; so much so, that some parts of it constitute almost pure bog iron ore. In no more striking manner can its immense relative antiquity be illustrated than by comparing its highly oxidized condition with that of the over-lying till. While the later boulder clay is oxidized only a few feet in depth, this earlier deposit is oxidized and cemented throughout a depth of at least 20 feet. Even beneath the Rhodenizer Lake kame it is just as highly oxidized as elsewhere, although over 30 feet, and formerly 60 feet, of stratified beds covered it.

Extent.—It seems to have formerly masked a large part of the province, since it is found at widely separated points, as Bridgewater; Greenfield, Queens County; Maitland, Lunenburg County; and the Grove, Richmond, which is within the limits of the City of Halifax. The depth to which it covered the country was no doubt considerable, as it is found in the Lahave valley from the sea level to 200 feet above it.

Origin.—That this deposit is not pre-glacial or inter-glacial, its unstratified condition decides. That it is glacial the presence of striated boulders testifies with no little weight. That it is of northern origin is proved by the contents, which consist of slate from near by, quartzite from the north-west, granite from the

central watershed, diorite from the south side of the Annapolis valley, and trap from near the Bay of Fundy.

First Interglacial Epoch.

To this epoch evidently belongs the Rhodenizer Lake kame, and the lower part of section 1 at Blockhouse. The evidences of their position and antiquity are :—

1st. At Blockhouse, section 1, we have 2, *a*, blue clay, with local drift; *b*, stratified soft red gravelly clay; *c*, bog iron ore, underlying the lower boulder clay.

2nd. At Rhodenizer's Lake the kame seems to be overlaid by boulder clay, and underlaid by the Bridgewater conglomerate.

3rd. This kame is more highly oxidized at a depth of 30 feet than the boulder clay at a depth of 5 feet. At Blockhouse also, the bog iron of section 1 is over one foot, showing an interglacial period of considerable length.

4th. The Rhodenizer Lake kame seems to have suffered great denudation on its western side. What remains seems to be but a fraction of its former size.

5th. Rounded, oval, and smoothly polished pebbles of quartz and crystalline rocks have been found in the lower boulder clay at Blockhouse, and which, no doubt, were eroded from an earlier water-worn deposit, such as the Rhodenizer Lake kame. The difference between the semi-angular boulders of the lower till, and the polished pebbles scattered among them, was at once noticeable and bespoke for the latter a far greater age.

Since the re-excavation of the pre-glacial valley of the Lahave, I cannot conceive how the conditions could have been favourable for the formation of the Rhodenizer Lake kame on the watershed to the east.

That the Lahave was re-excavated before the deposition of the lower boulder clay, is shown by the presence of that deposit in the valley at tide level two miles below Bridgewater. The formation of the kame and the re-excavation of the valley must have been contemporaneous, as the deepening of the latter and

its tributaries, and the consequent draining of the watershed at Rhodenizer's Lake, would have prevented the formation of the kame. If, as is maintained, this was near the southern limit of glacial extension, then the deep valleys to the east and west of this tableland would influence the course and lessen the eroding power of the thinned-out extremity of the last glacier. The complete removal of a kame on a watershed would then be extremely doubtful. Again, the formation of interglacial kames was but the natural result of influences then in operation. The retention of interglacial, as well as pre-glacial deposits, while being over-ridden by glaciers, was also but a common occurrence.* River terraces must also have been formed from the debris resulting from the re-excavation of the Lahave in this epoch. But whether their remains are represented by the deposits on the river east and south of Bridgewater, I had no time to attempt to decide.

Second Glacial Epoch.

To this period probably belongs the lower till of Blockhouse and Dorey's Brook, and the morraines surrounding them. It is seen filling the re-excavated valley of the Lahave at tide level, without having been there modified to any noteworthy extent. At Blockhouse it underlies the auriferous drift, and at Dorey's Brook it is seen beneath the interglacial clays and upper or auriferous beds, which last are of local origin. This lower till contains trap, granite, diorite, slate and quartzite. These rocks are sometimes much worn, but are generally semi-angular and easily distinguished from the rounded and polished pebbles included among them, and which were evidently eroded from some earlier deposit. It is but slightly oxidized where it is covered by the upper auriferous drift, showing that no very long time elapsed between the deposition of those two deposits. The course travelled by the drift, from the lode at Blockhouse was about S. 22° E. This may be a local deflection, as the

* Chalmer's Report on the Surface Geology of Eastern New Brunswick, 1895, page 47 ; M. also, Acadian Geology, 2nd ed., page 68.

general course of the striæ on the highlands around, is about S. 45° E., while the course of the valley in which the lode lies is about S. 50° E.

At Dorey's Brook, a thin bed of partly oxidized boulder clay containing granite and other northern drift, laid on the bed rock; while in the layers above, granite was absent. A large morraine, 2½ miles southeast of Dorey's Brook, contains much northern drift, with quartz, easily recognized as coming from a vein a little east of the brook. Their travelled course was about S. 40° E. The lower till, where covered by an upper layer of later origin, is but slightly oxidized, and in some places not at all; but this is probably owing to subsequent denudation, I have not been able to divide the till of the northern part of this district into an earlier and later deposit. The inference from this seems to be, that the next interglacial recession did not reach to the northern part of the area under discussion. A single deposit would there include what is represented further south by the deposits of two apparently distinct glacial epochs separated by a short interglacial period.

Second Interglacial Epoch.

This should be classed as a slight re-cession of the glaciers, rather than an interglacial epoch. The evidence at hand seems to indicate that while there was a re-cession of the ice at Blockhouse, it did not retire as far north as the granite, or even as far as the next quartzite belt, two or three miles distant. However, in its effect upon the purpose of my work, viz., the discovery of a gold bearing vein, it was adequate to an ordinary interglacial epoch, as it divided the drift into two portions, differing in character, condition of contents, and in the course traversed by it. The deposits belonging to this epoch consist, at Blockhouse, of red and yellow ochreous clay, (see section 2); finely stratified sand, (section 3); thin bed of bog iron, (section 4).

At Dorey's Brook are various coloured clays underlaid and overlaid by unstratified drift (see section). The overlying drift in all these sections is of local, and the underlying drift chiefly

of northern, origin. This shows that the ice sheet did not recede far enough to gather before it in its second advance any northern drift, while the slight oxidizing of the lower beds reveals a length of time which is very limited when compared with that of the first great interglacial epoch. This epoch is often represented by a slight denudation of the oxidized part of the underlying boulder clay.

Third Glacial Epoch.

This, the last invasion of this district by the ice sheet, has left as its legacy the local auriferous drift of Blockhouse and Dorey's Brook. In both these places it was probably gathered from exposed hummocks and loose debris in the immediate neighbourhood. It consists largely of angular slate boulders and oxidized clay and gravel, with here and there a few boulders eroded from the lower till. The most noteworthy point in this deposit, aside from the fact that it contains the gold-bearing drift of Blockhouse, is that the direction of its movement is different from that of the lower boulder clay. While the course of the latter has been about S. 22° E, that of the former has been from S. 50° to 55° E. Thus, while the underlying drift has been subject to continental or at least provincial influences, the upper drift is local both in composition and course of movement. At Dorey's Brook, also, the course travelled by the upper drift is influenced by the local surface contour. Its course is about S. 65° E., while that of the quartz in the interglacial clays is N. 80° to 90° E., and the underlying boulder clay probably S. 40° E. The tracing of the course travelled by the different layers of drift, is often a painstaking and difficult study, where no striations are left as a guide. But once its origin and the course it has travelled are known, it becomes our most reliable guide in the search for gold-bearing veins, and as such will repay the most patient investigation.

Post Glacial Epoch.

The deposits of this epoch consist of modified drift and river terraces. At this time the land appears to have been more elevated than at present, during which the beds of many of our

rivers were deepened. This I attempted to show in a paper read before the Institute on February 8th, 1892. These old river beds now form the channels of many of our harbours. Their formation has been ascribed to the tides, but apparently nothing less than the disjointing action of frost, aided by the attrition of rocks and gravel urged on by a rapid torrent, could cut away those deep and precipituous channels. The modifying influences of this epoch have had a very important effect on the distribution of the drift in some of our gold districts. At Blockhouse, however, it did not disturb the upper deposits to any appreciable extent, so we gave it but little attention.

As the deposits of the recent era merge into those of the historical period, I shall not deal with them. Several facts which have lately come to my knowledge possess a peculiar interest, inasmuch as they throw some light on that dim period that connects the historical with the geological history of Nova Scotia. They deserve a critical examination and a more extended notice than I am able to give them.

GENERAL CONCLUSIONS.

As this paper is already probably too long, I shall conclude it with the following remarks. That there has been a time when a continental glacier ploughed its way across the Bay of Fundy and the Province of Nova Scotia, seems to be beyond doubt, notwithstanding recent assertions to the contrary.* The alternative of a local or provincial ice sheet, is not in accordance with well-known facts except in the latest stages of the ice age. How otherwise could boulders of trap from the Bay of Fundy surmount the central watershed, and be distributed over the whole southern slope from Halifax to Yarmouth? They are not a chance occurrence, but are found in abundance in nearly every morraine and kame. How could a comparatively thin ice sheet flow along such a gentle descent as 1 foot in 340, unless it had the powerful influence of a continental glacier to

* See Chalmers Report on the Surface Geology of Eastern New Brunswick, 1895, pages 95 and 108.

back it? If we choose the latter as the cause of many of our phenomena, we have the following succession of events. They are numbered to accord with the supposed corresponding deposits in the sections before given :—

1. General glacial epoch: Nova Scotia covered by a continental glacier which masked the country with an enormous thickness of glacial debris of northern origin.

2. Interglacial epoch of considerable length, during which the pre-glacial valley of the Lahave was re-excavated to its former depth, immense kames formed, and the remaining drift oxidized more completely than any recent deposit. As a proof of the enormous length of this interglacial epoch, nothing is more convincing than the complete oxidization of these underlying deposits compared to the relatively slight change of a like nature wrought in ordinary boulder clay of a more recent date. The development of the *Pithecanthropus erectus*, with its 1000 cubic centimetre skull, is no surprise when such lengthened periods are dealt with (pardon this digression.)

3. A glacial epoch of shorter duration and less intense action. This was probably divided into two lesser epochs near the southern limit of its extension by a slight recession, and thus gave rise to the upper and lower deposits of Blockhouse. There was probably a repetition of such recessions and advances, until the general ice sheet dwindled to a local ice field and finally disappeared.

4. A local recession at Blockhouse, as mentioned above, during which a few beds of clay, sand, and bog iron were deposited.

5. A slight re-advance of glaciers on courses governed by the local surface contour. In its bearing on the deposition of the auriferous drift at Blockhouse, this re-advance was adequate to a separate glacial epoch, and from a miner's stand-point will have to be treated as such.

6. Final retreat of glaciers, formation of river terraces and general elevation of the country, during which our now submarine river channels were excavated.

7. Recent subsidence of our southern coast, as our buried forests and peat bogs indicate.

As is well-known, the study of glacial geology is of vast importance to the future of gold mining in Nova Scotia, and the discovery of important lodes are even now depending on a true explanation of the mysteries which surround the deposition and distribution of those deposits. What makes the matter very intricate, is that each district has been subject to local as well as general influences, thus necessitating a thorough local investigation before any trustworthy conclusion can be arrived at. Neglect of such a thorough investigation has been the chief cause of the many failures in the search for gold-bearing veins in Nova Scotia. But the days are fast going by when the working miner looked with supreme contempt on the study of geology as the hobby of a few students and men of leisure. It has been said that the science of the past will be the common-sense of the future, and the writer can make no apology for this article other than that he is contributing his feeble efforts to bring about this much-desired end.

VI.—NOTES ON THE SUPERFICIAL GEOLOGY OF KINGS CO., N. S. BY PROF. A. E. COLDWELL, M. A., *Acadia College, Wolfville, N. S.*

(Read 13th January, 1896.)

Kings County has an average length and breadth of 35 by 25 miles, but within this somewhat limited area there is very much to interest the student of geological phenomena.

Facing the Bay of Fundy on the northern side, and protecting the rest of the county from the chilling fogs, somewhat too prevalent in that arm of the Atlantic, stretches the noted trap ridge, known as North Mountain. This extends eastward from the Annapolis boundary to the famous Cape Blomidon, where it takes a northerly direction, then doubling on itself stretches westward till it terminates in the rugged but picturesque cliffs of Cape Split. The length of this ridge in the county is fully 45 miles, and it can be traced under the waters of Minas Channel for a long distance, making the rips off Cape Split and also those off Cape d'Or on the Cumberland side of the Channel. On the south of this mountain lies a valley with an average width of about 6½ miles. The surface rock here is Triassic sandstone underlying the trap at their junction, as is well seen at Cape Blomidon. This valley is drained by four rivers, the Pereaux, Habitant, Canard and Cornwallis, flowing eastward into Minas Basin, and having at their mouths large alluvial deposits composed of the comminuted sandstone and trap deposited daily by the tides. On the Canard river alono 2500 acres of this have been reclaimed, making most valuable hay-land. On the south of this valley, and generally parallel to the North Mountain runs the South Mountain range. At Gaspereau Lake this subdivides making the narrow valley of the Gaspereau River. The spur or offshoot of the South Mountain has its greatest altitude in Canaan, whence with a gradual descent it runs in the rear of Wolfville, and terminates at Horton Landing.

The southern part of the county is elevated, and is mainly covered with forests interspersed with lakes. Vast masses of granite form the outcrop.

GEOLOGICAL HORIZONS.

The northern part of the county, including the trap ridge and the valley sandstone, is without doubt Triassic, as it conforms to the triassic formations in other parts of the continent. This was a period when the weakened crust was unable to withstand the upward pressure of the molten rock and it burst through making long ridges or dykes. The original amount of this material must have been enormous, as it can now be found as drift extending south over the province to the Atlantic ocean. The Cornwallis sandstone, like other red rocks, contains no fossils, but its age can be inferred as above from its relation to the trap.

The rock of the South Mountain is a hard shale, for the most part often carrying veins of quartz. Quartzite also occurs in large masses in the vicinity of White Rock and stretches across the Gaspereau, making rapids in that river. In Webster Brook, two miles south of Kentville, in fawn-colored slates, Dictyonema Websteri is found, probably Cambrian, and on Canaan Mountain, one mile further south, Silurian encrinites may be obtained. The ridge south of Wolfville contains no fossils, and the mountain still further south is also barren, but a little to the eastward the brooks running into the Gaspereau show in their beds abundance of plants, *lepidodendrids*, *sigillarids* and *calamites*. These fossilliferous rocks continue to the extreme east of the county, Horton Bluff, and are probably sub-carboniferous, though some of the western series may be Devonian. In the eastern part of the town of Wolfville, running south from the dyked marsh to the top of the ridge and reappearing on the south of the Gaspereau River, is a deposit of varying width known locally as "Wickwire Stone." It is a coarse friable sandstone or fine conglomerate, the sharp grains of quartz being held together by a red cement of ferric oxide. It is largely quarried, being the principal material used for the foundations of buildings in this

vicinity. It some instances it resembles the triassic sandstone, but differs from it in containing no calcium carbonate. I have traced this formation to within a short distance of the shale but have not been able to observe the junction of the two. Its age has not been accurately determined, but it may be sub-carboniferous.

EVIDENCES OF GLACIATION.

Drift material from the North Mountain abounds on the South Mountain, being especially plentiful in the gulches and beds of brooks. This is mainly Amygdaloidal trap, which, notwithstanding its tendency to decompose through weathering, is found in somewhat large masses. In Wolfville, it is found in the soil to a considerable depth, especially along the line of a former beach. I have also found small boulders of syenite and diorite, which must have come from the Cobequid Mountains, as they resemble the rocks found in that range, and are unlike any country rock I have seen on this side of the Minas Basin.

STRIÆ.

On the summit of the ridge south of Wolfville, in the hard, fine-grained shale exposed on the side of the highway, parallel markings may be seen in different places, evidently glacial striæ. I have also observed coarse markings on a freshly exposed surface of Wickwire stone. These scorings all trend in a south-easterly direction.

EVIDENCES OF ELEVATION AND SUBSIDENCE.

The encrinites found on New Canaan mountain indicate that that formation was at one time covered by the sea, but its present altitude is probably due to the upthrust of the mountain range as distinguished from elevation over large areas. There is good evidence, however, that the sea was at one time nearly 50 feet higher than at present in an old beach formation, extending along the line of Acadia Street, parallel to the present water frontage. This, wherever dug into, presents a similar structure of rounded stones, evidently well worn by attrition. Immediately to the south of this, and at a higher elevation, is a

deposit of clay, while in front, about thirty feet lower, is a deposit of fine sand. The rounded stones in this old beach are mainly trap, so that the formation is of comparatively recent origin, probable Quarternary. At this time the sea must have covered the whole of the Cornwallis and Annapolis Valley.

There is also evidence that the land must have been at one time considerably higher than at present, for on the northern side of Long Island, about thirty feet below high water mark, are the remains of buried trees, *in situ,* the stumps, roots, and even trunks well preserved. This would call for a subsidence of 40 to 50 feet.

VII.—On an Arborescent Variety of *Juniperus communis*, of Linnæus, occurring in Nova Scotia, and not previously noticed in our Flora.—By J. Somers, M. D., *Halifax, N. S.*

(Communicated 11th December, 1893 ; received 15th April, 1896.)

Some time ago my attention was directed to a variety of our common juniper not commonly met with. Mr. William Gibson of this city, had for some years given much time to investigating the subject. He introduced me to several arborescent junipers, some of them, one at least, growing to the size of a lofty shrub. Another, he tells me, grew to the size of a small tree, the bole of which he judged would be four inches in diameter. The locality of these was on the Dartmouth shore of the harbor, near the old windmill. The larger one, which I did not see, grew on the Halifax side, near the Cotton Factory road. He informs me he has been observing the growth of the shrub juniper for over twenty years. Some have disappeared in process of clearing, others still remain. At the time I visited the place where most of those plants grew, Mr. Power, of the Public Gardens, procured several specimens for transplantation. I think I am correct in stating that some success was attained in this. I know from experience of earlier years that though the low juniper was common in our vicinity, the shrub form was not. With us, the ordinary conception of *juniperus communis* is of a low shrubby plant, decumbent, froming a circle of growth from the centre towards the periphery, the patches varying from two to six feet in diameter, depending on the surroundings, rarely rising in growth two feet above the surface, the tough fibrous roots spreading themselves somewhat deeply in the soil.

The juniper here presented departs widely from the method of growth described above. It rises upward in a form beautifully symmetrical, assuming the proportions of a shrub with numerous branches, and root stocks ascending and adpressed to

the parent stem, attaining the height of fully fifteen feet in old plants, forming a column cylindrical and varying in circumference, in the largest one seen, I should say, about five or six feet, a beautiful column of greenery, surpassing in appearance many exotic cultivated species of its tribe.

Studying this juniper from a botanical view, the sole difference presented to us is the difference in growth between it and the ground juniper. In foliage, infloresence, and fruit they are alike. The only question is, from its mode of growth should we describe it as a marked variety. In the locality where the upright plants grew were many circles or saucers of the low growing plant. In some of these the terminal (peripheral) branches showed a tendency to upward growth. Individual, central branches grew upwards a foot or more above their neighbours. Some arborescent plants seemed to rise from prostrate roots. They, however, did not assume the perfect cylindrical form of the true shrubby plants which we found growing independently and remote from the ground-lying form. The fact seemed that upgrowth exists most strongly in isolated plants of this kind. The individual difference between the junipers mentioned above is so great as to the eye of any ordinary observer, even though having botanical knowledge, to cause the supposition that they were distinct species. Closer observation, however, convinces that the plants are the same though varying in growth.

We will, for descriptive purposes, take first, Linnæus's diagnosis of his *Juniperus communis* from the *Sps. Plantar.*, 1470, viz.: " A large shrub, extremities of the branches smooth and angular; leaves in threes, linear, accrose, sharply mucronate, shining green beneath, but with a glaucous line along the centre of the upper surface, they are resupinate, turning their upper surface to the ground; barren flowers in aments, small, axillary, with roundish stipitate scales, enclosing the anthers; fertile flowers on another plant having a small, three-parted involucre growing to the scales, which are three; fruit fleshy, berried, of a dark, purplish color, formed of the confluent succulent scales,

which are marked with three prominences, or vesicles, at the top, and contain three seeds." We have in the above a perfect description of our arborescent juniper drawn by a master hand.

Periera, English medical authority, thus describes *Juniperus communis*:—"Leaves three, in a whorl, spreading, linear, subulate, mucronate, longer than the galbulus; a bushy shrub, flowers sessile, axillary, male and female flowers separate; fruit called a berry, in botany a galbulus, requires two seasons to arrive at maturity, black with blue bloom not more than half the length of the leaves."

Louden, in his *Arboriticum*, Vol. IV., p. 2489, mentions seven varieties, some of which he says are probably distinct species. "One juniper, Nana (Smith), procumbent stems, imbricated, incurved; leaves, linear, lanceolate, fruit nearly as long as the leaves, endigiment in mountains."

Prof. Amos Eaton, *Manual of Botany*, sixth edition, pub. Albany, 1833, by Oliver Stub, gives, from an American view, a diagnosis like that of Linnæus, though he calls the plant "*Juniperus communis*, Willd." He mentions two varieties:—

" Var. 1, *erecta*, branches erect.

" 2, *depressa*, branches prostrate, or horizontal." He gives no details as to appearance of *erecta*, except the above.

Wood, in his class book, gives "a shrub, with numerous prostrate branches, growing in dry woods and on hills, often rising in a slender pyramid six to eight feet high." He quotes Robbins as saying it is rarely arborescent. This, of Wood, agrees with our shrub. He gives no varieties. Gray is very indefinite. After the usual diagnosis he says: "Low shrub, ascending or spreading on the ground (Europe)." It requires some botanical skill to evolve our juniper out of this.

Taking all the above statements into consideration, I am of opinion we have two varieties of *Juniperus communis*, Linn.; one most common, decumbent, the other uncommon, shrubby.

Since writing the above I have received from Prof. George Lawson, LL.D., the following valuable information which he

kindly forwarded to me to help out my notes on the Junipers, for publication in the Proceedings. It is dated January 5th, 1895:

DEAR DR. SOMERS,—

On reference to Endlicher's *Synopsis Coniferarum*, published at Cracow, in 1847, I find that he describes four forms of *Juniperus communis*, viz.:—

(a) vulgaris.—Shrubby, with spreading branches and spherical berries.

(b) Hispanica.—With ascending straight branches, and egg-shaped berries.

(c) Caucasica.—With divaricate spreading, somewhat pendent branches, leaf clusters or verticils distant from each other, berries ovate.

(d) arborescens.—With ascending straight fastigiate branches, forming a top.

In Koch's *Synopsis Floræ Germanicæ*, edition of 1844. *Juniperus communis* is described as shrubby *(fruticosus)* erect, becoming arborescent.

In the English Cyclopedia (Nat. Hist., vol. iii, p. 311,) it is stated that juniper occasionally becomes a small tree.

The French dictionaries give the name Genevre, *Juniper;* Genevrier, Juniper tree. The name of the old town of Geneva is said to be derived from the juniper, as are obviously the names in modern European languages of the fermented liquor called Geneva, obtained from juniper berries, and the distilled spirit from grain flavored with these berries, called Holland gin, the latter being a contracted corruption of Geneva.

In the *Flora Rossica* of Petrus S. Pallas, a large folio of magnificent colored drawings, published at St. Petersburg, in 1784, by command by Catherine II., the *Juniperus communis,* is described as growing in sterile, sandy places and woody hills throughout the Russian empire, frequent in the northerly and temperate regions, occurring also in the southern mountain tracts, as in the Taurian Chersonese, about Sudak, Balaklava, Lambat, and Sebastopol Harbour, also in the

Caucasian promontory, viz.: "Mostly shrubby, but in the temperate and southern parts with well-marked erect stems, but in Siberia almost always shrubby." The remark is made by Pallas that this plant is so common and well-known in the use of both the berries and wood that it is not necessary to inform Russians on this point.

Yours truly,

GEORGE LAWSON.

The recent lamented death of Dr. Lawson, pioneer botanist of Canada, will, I am sure, invest this communication of his with great interest to those who, knowing him, admired him, as being probably among the last of his writings upon the science so endeared to his heart.

VIII.—Some Nova Scotian Illustrations of Dynamical Geology.—By Prof. L. W. Bailey, Ph. D., LL. D., *University of New Brunswick.*

(Read 9th March, 1896.)

The following notes and accompanying photogravure plates are designed to present to students of the geology of Nova Scotia a few phenomena and results which seem to the writer sufficiently remarkable to deserve some special notice. The notes and pictures were all taken in connection with the work of the Geological Survey of Canada, and are reproduced here by the kind permission of the Director.

I. SAND HILLS OR DUNES OF THE SOUTHERN COAST.

At several points along the shores of Queen's and Shelburne Counties the attention of the traveller is attracted, even in mid-summer, by what appear, in the distance, to be great drifts of snow. Especially is this the case in driving along the post-road at the head of Port Mouton Harbor, whence, though at a distance of a mile or more, such drifts, in reality of blown sand, are readily seen, forming indeed a conspicuous feature of the landscape. They here occur upon the *west* side of the indentation named, stretching along the latter, though somewhat interruptedly, for nearly a mile, and attaining in places a height of thirty or forty feet. They conceal for the most part from view the underlying rocks, but these, as seen in several islands near by, are undoubtedly granitic, and such as, by their decomposition, might readily afford the pure white siliceous sand of which the dunes consist. This sand is almost wholly incoherent, and readily blown to and fro by the winds, while, near the water's edge, quicksands occasionally become a source of danger to the incautious traveller; but why so great an accumulation of such material should take place at this particular spot is not directly obvious.

The difficulty referred to, as to the location of the Port Mouton sand-hills, is enhanced when with these we compare the similar hills of blown sand which form portions of the shore of Barrington Bay. The accompanying Plates, VII and VIII, will give a good idea of these, as regards both the extent of the area they cover, the height to which in places they have been heaped up and the fact that they are still travelling inland, burying bushes and even forests as they go. I am without any exact measurements as to the area covered, but think that this cannot well be less than fifteen or twenty acres, while the height of the hills, which is greatest at the inner margin of the area, is probably not less than forty feet. It is said that a portion of the area, (which is on the lower part of Village-Dale,) was once occupied by a French village. However this may be, it is certain that the hills are gradually travelling inland, and that each year adds appreciably to their height as well as to their distance from the sea. In all these features they nearly resemble the sand hills of Port Mouton, but in two other important respects there is a noticeable difference. In the first place, while the dunes of the harbor last named are upon its *western* side, those of Barrington Bay are upon the *eastern* side of that indentation; and, secondly, while in the former instance the rocks at hand are granitic, and well adapted to yield the necessary material for these accumulations, the sand-drifts of Barrington Bay rest on beds of Cambrian slate and quartzite. It is true that there is abundance of granite at the head and upon the west side of this latter Bay, but this is several miles distant.

It is therefore again difficult to see what have been and are the special circumstances which have led to the production of such large deposits of such material at this particular spot. It is also difficult to see wherein either of these spots differs materially, either as regards exposure to the winds, nature of the rocks, or in other respects, from innumerable other localities along the shore, in which no trace of such deposits is to be found. Possibly further and closer study may remove the difficulties of explanation which now exist.

II. GLACIAL TROUGHS.

It is probable that most observers are familiar with glacial markings or striations, the scores left by the great ice-sheet of the Glacial Period in the course of its movement southward, and which are abundantly exhibited in the Park and elsewhere about the City of Halifax. But probably few, if any, have seen such a proof of the power of ice action to carve the surface over which it moves as is afforded in the photographic plate No. IX. This remarkable view was taken on Lockeport Island, within ten or fifteen minutes walk of the town of Lockeport. The rocks at the place are Cambrian slates and quartzites, the latter predominating, in beds 10 to 15 feet in thickness, and dipping south-easterly at an angle of about 50°. The trough, which is plainly shown in the picture, runs in the direction of the beds, and, no doubt, owes its origin in part to that fact, and to the unequal hardness of the two kinds of rocks which the strata contain; but even with all allowance for such favoring circumstances, the magnitude of the result is not only unusual but phenomenal. Not having any means of exact measurement at hand, the writer is unable to give precise data as to the dimensions of the trough, but is safe in saying that its length was at least 30 feet, its depth at centre at least 4 feet, and its breadth as much as 4 or 5 feet, the larger part being in massive quartzite. The form of the trough, as seen in the view, was in section not unlike that of a canoe, the sides curving gracefully down to the middle line, while, along the same sides and parallel with the axis of the trough, were numerous striations of the ordinary kind, also clearly seen in the photograph, and leaving no doubt as to the nature of the agent to which the trough itself is to be ascribed.

A trough of such magnitude, due to glacial erosion, is certainly a very unusual occurrence, at least in this part of the world; but, remarkable as it is, it in turn sinks into insignificance in comparison with some other troughs, due to the same agency, which were subsquently seen. These occur about midway between Port-la-Tour and Baccaro, on the coast of Shelburne County, and upon a small point, which is almost an island,

locally known as Crow's Neck Point. The rocks here are mica-schists, conspicuously studded with staurolitic crystals, as well as with irregular knobs or blotches, (some 6 x 3 or 4 inches in size,) which are in part at least half-formed crystals of andalusite. The rocks are massive but distinctly bedded, with a S. W. dip of 20°; and at right angles to this dip runs a trough or gully, similar in character and doubtless in origin also, to that of Lockeport Island described above, but in this instance *not less than 20 feet broad and 20 feet deep!* The sides, as before, curve regularly to the axis, and are everywhere smoothed and striated along lines parallel to the latter.

It is to be regretted that the writer, at the time of his visit to this locality, was unprovided with a camera. A view of this trough would, however, be less satisfactory than that of Lockeport Island, as in this instance the trough is in part occupied by a large boulder (possibly concerned in its origination), which somewhat obscures the prospect. Other troughs of less magnitude, but yet of unusual size, are found in the same neighbourhood.

III. ERRATICS, MORAINES, KAMES, ETC.

Nova Scotia presents, almost everywhere, abundant opportunities for the study of surface geology, more particularly as dependant upon the ice-movements and probable general glaciation of the Pleistocene Era; but nowhere are such opportunities more forcibly pressed upon one's attention than in the south-western counties. Some of the facts there exhibited have already been made the subject of comment by the writer, as well as by others, in the Proceedings of the Institute. It is not the intention of this paper to discuss them further here, but only to direct attention to a few localities in which they are especially noticeable.

Boulders.—Of boulder-strewn districts probably none is more remarkable than that of the tract lying to the north-west of Lake Rossignol in Queen's County, and along the county lines separating Digby County from Shelburne and Yarmouth. Here, over an extensive tract, including the so-called Blue Mountains,

boulders of granite completely hide from view the underlying ledges, and attain immense size. One, north of Pescowess, according to observations by Mr. W. H. Prest, was 35 feet in height above the debris in which it was imbedded, while another in the same vicinity, was 47 feet long, 22 feet wide, and 15 feet high, or 15,000 cubic feet, and would weigh over 1000 tons. Only those, who, like Mr. Prest, have traversed this district, can form any idea of the extreme difficulty involved in so doing, or of the wild, weird and indescribably desolate aspect which it everywhere presents.

A boulder of somewhat smaller dimensions, but still a giant, and one which is more accessible, occurs upon the Liverpool River, about four miles above Milton. It is composed of grey micaceous sandstone, with slaty layers, and is 30 feet long, 15 feet wide, and 20 feet high.

In the vicinity of Shelburne there are also many large boulders, particularly on the west side of the harbor, towards its head, where they have, in many instances, been the basis of the quarrying and stone-cutting operations carried on here.

Finally, on the west side of Petite Passage, between Digby Neck and Briar Island, and overlooking the village of Tiverton, is a very remarkable assemblage of detached blocks of rock. Like the beds on which they rest they are composed of trap, but in what way they acquired their present position and character is by no means obvious. They are of immense size, and both individually and in their grouping, exhibit features which border upon the grotesque. Were they at the base of a cliff they might well be the fragments detached from its brow and piled one upon another, but here they are at the top, not the base, of the cliff, and most numerous near its edge, where they stand like sentinels, 100 feet or more above the swirling waters which they overlook. Are they the remains of a lateral moraine, formed in connection with a glacier which once traversed and perhaps made the Petite Passage? The occurrence of glacial striæ along this passage and *at the water's edge*, as seen at Israel Cove, lends some countenance to this supposition.

It is not probable, in any of the cases above cited, that the distance of boulder travel has been great, the rocks being similar in nature to those occurring *in situ* at points not widely removed. Of true *erratics*, or long distance boulders, the most noticeable, perhaps, was one of dark grey felsite-conglomerate, seen in Tiverton, near the middle of Petite Passage, and probably not more than 20 or 30 feet above the level of the tide. No rock of this character has yet been observed in south-western Nova Scotia, but it is common in southern New Brunswick, whence in all probability it was derived. Granite boulders were also observed in this vicinity, as well as on Briar Island, which may also have come across the Bay, though possibly derived from the granite of the Blue Mountains in Nova Scotia, some 40 miles distant. Boulders of the traps of Digby Neck are occasionally met with over all the south-western counties, even as far as the Atlantic shore.

Of ordinary terminal *Moraines*, the interior of Queen's, Shelburne, and Yarmouth Counties affords many examples, and to their presence and influence many features in the drainage of the country are no doubt due. The headwaters of the Port Medway, Liverpool, Jordan, and other rivers may be cited in illustration. In a similar way some of the islands off the coast, and particularly those which, in such large numbers, dot the surface of Tusket Inlet, are, in all probability, of morainic origin.

In addition to moraines, the peculiar accumulations known as *Kames* or "*Horse-backs*," are abundant in south-western Nova Scotia, and are, in some instances, of remarkable character. A ridge, which is probably of this nature, crosses the Liverpool and Annapolis road in the northern part of Maitland Settlement, whence it was followed by W. H. Prest in a direction E. or ENE., across the Maitland River to Gull Lake, and then northerly, by Gull Lake Stream, to the south of Perrot's Settlement, while in the opposite, or westerly direction, it was similarly followed, westerly or west by south, by way of Long Lake to Frozen Ocean, finally crossing into Digby County, south of the Sissaboo. A peculiarity in this case is that, while consisting, like other

kames, partly of sand and gravel, the main source of its materials, blue slate, would seem to have been derived from the south, not from the north, and from beds which are somewhat remote. The course of the ridge, across the general slope of the country and parallel with the coast, is also peculiar, suggesting a possible beach origin.

Other good examples of kames or gravel ridges are to be seen in Shelburne County, between Clyde Village and Port Clyde, and at the head of a long, narrow promontory separating Negro Harbor from Port la Tour. In each of these cases the ridges are several miles in length, somewhat tortuous in their course, but with a general southerly trend, are from 20 to 40 feet high, and usually just broad enough at top to afford room for a roadway, a use to which, in both of the instances given, they have been applied.

But by far the most remarkable of such ridges is the so-called "Boar's Back" of Digby County, the total length of which, though somewhat interrupted, cannot well be less than twenty miles. The best place for its examination (where also are the "moving stones" referred to in Lord Dunraven's account of his travels in Nova Scotia, regarded by him as inexplicable, but the result, probably, of the expansion of lake ice), is on the "Hectanooga Road" in Yarmouth County, a short distance north-west of where this joins the Weymouth Road, near Wentworth Lake.* As usual this kame consists of sand and gravel, with some imbedded boulders, and also, as usual, it is bordered on either side by extensive low and flat tracts, occupied mainly by bogs and barrens. In a few instances, as on the Jordan River, above Jordan Falls, the kames are found to bifurcate, or to enclose deep circular or oval depressions, forming "kettles."

IV. UPLIFTS AND DISLOCATIONS.

Marine and River Erosion.—No finer opportunity for the study of disturbed strata could readily be found than that afforded by the south coast of Nova Scotia. Almost every

* See Church's Map of Digby County.

variety of folding, and through a scale equally various, is here exhibited; while the outline of the coast, distinguished by long projecting tongues of land and intervening narrow valleys or fiords, affording natural sections, make their examination unusually easy and attractive. The erosive action of the sea, as modified by the unequal hardness and the varying altitude of the beds, together with the positions, equally various, of bedding planes, cleavage, joints and fault planes, is also strikingly exhibited. Upon the coasts of Queen's and Shelburne Counties the rocks are either Cambrian quartzites and slates, or granite, and the former are generally, though not always, titled at high angles, the result of orogenic movements of which the date has not as yet been definitely fixed. A characteristic example of such tilted beds is to be seen on Lockeport Island, not far from the point exhibiting the glacial furrows already described. The ledges here exposed are composed of quartzite, dipping 40° or 50°, while the parallel troughs by which they are separated correspond to the softer and more easily removed slaty beds. A feature of additional interest in the case of this quartzite ledge, is the fact that, notwithstanding the metamorphism of the quartzite, which glistens with scales of mica, its surface shows a number of unmistakeable impressions of what have elsewhere been described as fossils under the name of *Asteropolithon*. The real nature of these impressions, however, (which may be well studied in the quartize ledges on the summit of the hills overlooking Bedford Basin,) whether really organic or only imitative forms of concretionary origin, is still disputed. If of organic derivation, (and some of the markings seem inexplicable upon any other view,) they probably represent the burrows and the radiating trails of marine worms.

While the southern coasts owe their peculiarities largely to the general presence of Cambrian quartzites or of granite, those of Yarmouth and Digby illustrate, in an equally striking way, the results of upheaval and of marine erosion where the prevailing rocks are slates. The most remarkable exhibitions of the effects due to these two causes are to be found about Point Fourchu, (Yarmouth Harbor), in the vicinity of Chegoggin Point, thence

northward to Port Maitland, and again between Cape St. Mary and Meteghan. All along this coast the strata are thrown into a series of short folds, usually oblique to the coast line, and are broken by numerous faults. To the north of Cape St. Mary Light, the shore is especially high and bold, presenting an almost endless variety of craggy precipices, overhanging bluffs, caves and "stacks," the latter sometimes of grotesque outline. There is seldom any beach, or any safe means of ascent or descent, so that any examination of the section must be made by boat, and even this method is possible only in the calmest weather. The views afforded, however, and the instruction to be gained, are well worth some little risk.

Among other incidents of marine erosion may be mentioned here the occurrence of some noticeable "spouting horns" near the extremity of Western Head, near Lockeport.

Besides the examples of folded rocks and of erosion to be found along the coast are those afforded by the rivers and streams of the interior. Of these in Queen's County one of the best is that of the Port Medway; in Yarmouth County, the Tusket; and in Digby County, the Sissaboo or Weymouth River. The section afforded by the latter is especially interesting for its variety and completeness, and as affording a key to the structure of a large part of this county. So also are the sections afforded by the Grand Joggins, Bear River, Moore River, and Deep Creek, on the south side of Annapolis Basin, as well as by the several smaller creeks emptying into the same sheet of water. In a single railway cutting, near the mouth of Bear River, may be counted not less than fourteen small folds, and as many as six faults.

At the head of St. Mary's Bay, and adjoining the so-called "Sea Wall," is a fine example of a *monoclinal block*, the red sandstones, of probable Triassic age, here forming a series of very picturesque vertical bluffs, rising to a maximum of a hundred feet, with a regular but low inclination northward, and affording many curious instances of marine sculpture in comparatively soft beds.

V. JOINTS, CLEAVAGE, ETC.

The divisional planes referred to above are of such common occurrence in regions of metamorphic or partly metamorphic rocks, such as form so large a part of Nova Scotia, as hardly to deserve notice here. And yet their recognition and distinction from each other and from planes of bedding is one of the most serious practical difficulties to be encountered by the field geologist, especially in the study of the Cambrian rocks of the southern coast. The quartzites of this system abound in joint planes, often causing them to divide into prismatic blocks, while the slates of the same system have in general a strongly pronounced cleavage structure. Both may be, and often are, much more pronounced than the bedding planes, so that strata which are really level-lying, or in low undulations, may present the appearance of being highly inclined. Such a condition of things is especially prominent over much of the country north of Caledonia in Queen's County, where, were it not for the fact that the rocks are strongly banded or ribbanded with somewhat strongly contrasted colors, indicating the true planes of deposition, mistakes might very readily be made as to their true position. Portions of the coast south-east of Lunenburg, where similar strongly ribbanded beds occur, afford other illustrations of the same fact.

Besides the joints which characterize the massive quartzites of the Cambrian, or the granite by which the latter is invaded, it is proper to notice here the similar divisional planes found in the traps of Digby Neck, Briar Island, &c. Some of the columns thereby determined are illustrated in Plate v. (Part 1 of the present volume of the Transactions,) as seen at Israel Cove on the Petite Passage, and others much more remarkable occur along the south side of Briar Island.

VI. METAMORPHISM.

Almost every stage of the metamorphic process may be well studied along the coasts of the south-western counties. The quartzites, as might be expected, show the least evidence of

change, the effect in their case being usually confined to greatly increased hardness and compactness, or to the development in the mass of mica scales and metallic sulphurets; but among the finer beds, now mica schists, the alteration is often much more extreme, the mica being not only far more conspicuous, but accompanied, often over large areas, by multitudes of staurolites and small garnets, as well as andalusites. The staurolites are often quite perfect and readily separable from the matrix, but the andalusites are rarely well formed or differentiated, shading into the associated rock, while they are themselves indefinitely penetrated by mica, garnet, and staurolite crystals. The best localities for the collection of staurolites are the vicinity of Jordan Falls, and the west side of Shelburne Harbor, in the village of Carleton, while both these and andalusites may be found in large numbers about Baccaro, on St. Anne's Point, in Pubnico, and about Brazil Lake and Lake Annis in Yarmouth County. The garnets observed upon the coast, though numerous and usually quite clear, were all small, while those of the interior, along the borders of the granite, while considerably larger, were generally dull. A somewhat remarkable example of this latter class is to be seen in the fields half a mile east of Brazil Station on the Dominion Atlantic R. R. in Yarmouth, the schistose rock having its surface thickly covered with projecting crystals of this mineral from the size of a pea up to a diameter of an inch or more. Rocks of very similar character occur about the shores of Lake George, and again upon the coast at Chegoggin Point. Near an old quartz mill in this vicinity is an 18 foot belt of garnetiferous schist, having cross veins of pure garnets mingled with hornblende and menacoanite. Along the same belt of metamorphic strata (between Yarmouth Harbor and Lake Wentworth) the rocks frequently contain scattered sheafs of hornblende, and in places become a nearly pure hornblende rock.

Quite a different type of metamorphism is to be found along the northern side of the great central granite tract in Digby and Annapolis Counties. Here the stratified rocks which adjoin the granite are of much more recent origin than those described

above, being of Devonian age, and in places filled with the characteristic fossils of that formation. The best opportunities for their study are to be found along the line of the Nova Scotia Central R. R., between Alpina and Nictaux Stations, (this interval being almost continuously occupied by rock cuttings, usually fossiliferous,) the east branch of Bear River, (a mile and a half above the head of the tide,) and in Mistake Settlement, between North and South Range, in Digby County. The strata include iron ores in addition to slates and sandstones, and the former as well as the latter carry organic remains. Near the granite the rocks assume more or less fully the character of gneisses, while the iron ores, elsewhere hematites, have become, in part at least, converted into magnetites. The fossils often show also the distortions due to the pressure they have undergone.

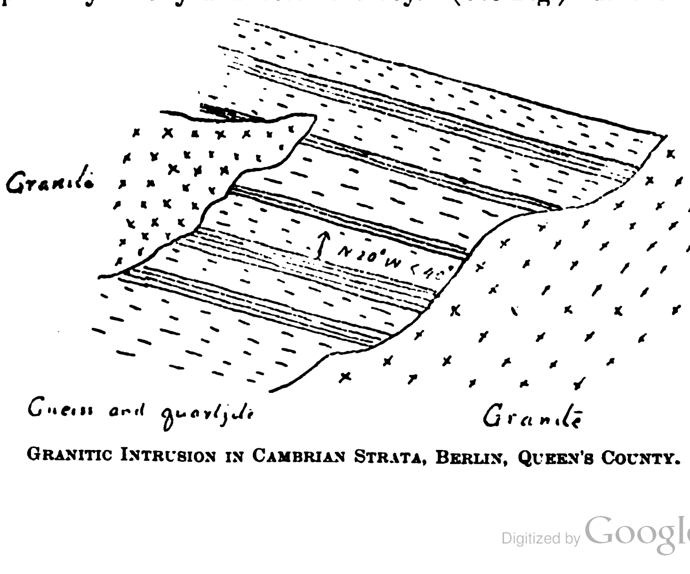
VII. VEINS, CONTACT PHENOMENA, ETC.

Space will not allow of any lengthy reference here to the quartz veins of the Cambrian system. Nor is this necessary, as their character and relations with the associated strata have been so fully described by earlier writers in connection with the development of the gold mines of which they form the basis. It will be sufficient, in illustration of their occasional magnitude, to refer to two instances only; the first, that of the "Jumbo Mine," in Westfield, Queen's County, with a width, though not wholly of pure quartz, of over sixty feet, while the second is that on which was located the stamp mill, referred to above, at Chegoggin Point, and which is about 26 paces across, of pure milk-white quartz. At this latter locality may also be seen an interesting example of *slickensiding*, the pure milk-white quartz of which the vein consists being divided by a vertical fissure or fault plane, of which one wall to an unknown depth has, by the friction accompanying the fault, been polished to the smoothness and brilliancy of a mirror. These large veins are, however, less auriferous than those of smaller size.

QUARTZ VEIN IN LAMINATED SLATES.

A singular instance of a very narrow but tortuous vein seen upon the shore about Eagle Head Breakwater, east of Liverpool Harbor, is here reproduced. The contortions are in exact correspondence with the corrugations of the enclosing strata.

Another type of veins of much interest is where these latter consist of granite, and, with other contact phenomena, finds abundant illustration at many different points along the borders of the principal granitic masses. A striking example of such a granite vein or dyke of large proportions may be seen on the shore opposite Coffin's Island, near the eastern head of Liverpool Harbor. The beds exposed here are chiefly gneisses, quartzites, and mica schists, of the Cambrian system, and have a very regular northward dip of 40°. Across these beds, however, and almost at right angles, run heavy masses of coarse white weathering granite, the dip and strike of the strata being apparently wholly unaffected thereby. (See Fig.) In the same



GRANITIC INTRUSION IN CAMBRIAN STRATA, BERLIN, QUEEN'S COUNTY.

vicinity a mass of granite, 20 or 30 feet wide, may be seen enclosed between tilted beds of quartzite and running for 100 yards or more in perfect conformity with the latter, then suddenly terminating. On the other hand on the Shelburne River, where crossed by the post road, may be seen a good illustration of the intricate blending of the granitic and schistose masses commonly met with along their lines of contact. Regularly stratified beds are, as before, abruptly cut off across their line of strike, long irregular tongues of granite invade the associated strata, and what look like detached blocks of the latter are sometimes completely enclosed by granite.

In the section on the Nictau River, already referred to, and just north of Alpina Station, is a good opportunity of studying the intrusion of granitic masses among Devonian strata, showing both the exotic origin of the granite and the period of its extrusion.

In connection with the granitic masses, both small and large, occur numerous veins in which the constituent minerals of granite, viz., quartz, felspar and mica, have been segregated out on a larger scale, affording fair specimens of each. A good illustration of such segregated veins may be seen at the western head of Liverpool Harbor, at the Government Breakwater, where, in addition to good specimens of felspar, may be found sheafs of pale yellowish plumose mica. In some instances these veins carry tourmaline and garnet as well as mica.

Still a third type of veins, abundantly illustrated in the region under review, is found in connection with the traps of Digby Neck. Like the veins in the Cambrian rocks, first described, these are usually silicious, but whereas the former are of pure milky quartz, with accompaniments of metallic sulphurets and gold, the latter are as generally highly colored and banded, including all varieties of agate, jasper, chalcedony, &c., as well as amethyst, while the associated minerals are calcite, zeolites of many varieties, together with oxides of iron (hematite, martite, magnetite). Simple veins of agate and jasper, from one quarter of an inch to a foot in diameter, may be seen almost anywhere

along the Bay of Fundy shore of Digby Neck, but are especially numerous and finely colored in the hills overlooking the Petite Passage, about Tiverton. Veins of iron ore occur three miles from Digby on the road to Broad Cove, at Johnston's mine, in Waterford, at Mink Cove, and elsewhere, while at Nichol's mine, in Rossway, are to be seen particularly interesting combinations or associations of all the minerals named above. A peculiar brownish white unctuous or soapy clay is another abundant and interesting accompaniment of the veins at this locality, filling the fissures of the rock in all directions and causing it to be locally known as a soap mine.

Veins of pure zeolites occur in various parts of Digby Neck, but less frequently than those of quartz or iron ore. *Thompsonite* is the one of most frequent occurrence, and is especially abundant on the Bay of Fundy shore at Broad Cove, seven miles from Digby, and again near Gulliver's Cove.

Veins of native copper may be seen on the eastern side of Digby Gut, near the entrance.

IX.—Phenological Observations made at several Stations in Canada during the year 1895.—Compiled by A. H. MacKay, LL. D., *Halifax.*

(Read 11th May, 1896.)

The phenological observations made under the auspices of the Botanical Club of Canada during the year 1895, are more extensive and more complete than those made during the previous three years. Among the observers there are some who have made (as will be seen in the following tables) valuable zoological and meteorological observations as well as the botanical ones. It was distinctly stated in the directions given observers, that sports out of season or due to narrowly local conditions of shelter, &c., which would affect less area than a small field, should not be recorded except parenthetically. As far as possible the observations recorded were the appearances of the *first* which was immediately followed by the *many* of the same kind. When phenomena are not very common in any specified locality, it can be readily understood that the first arrival may not be seen for some days after. This is a sonrce of error which cannot well be guarded against; as is also the impossibility of an observer's sometimes being able to make his complete tour of observation every day. Whatever defects may characterise any of these observations, I have reason to believe that on the whole they are becoming more accurate from year to year. It is to be regretted that there are still very many blanks at many stations; but a blank is infinitely better than a wrong figure. With reference to thunderstorms, it will be seen that many observers were not mindful of noting even those which occurred during hours when, not being asleep, they must have noticed them. However, as in the other cases, we must be content with such facts as have been recorded, remembering that there is no pretence to say that all have been recorded.

In connection with every school there should be such records kept and pasted into the Register for each year, or kept in a

special book,—all the pupils in the school, under the direction of the teacher, being utilized to their amusement and edification in observing throughout the whole school section each day when going to and returning from school. From such complete, well-checked and numerous observations, most valuable inductions might be made in the near future.

STATIONS AND OBSERVERS.

Nova Scotia.

Yarmouth.—Miss Antoinette Forbes, B. A.
" Miss Beth Lovitt.
Berwick.—Miss Ida Parker.
Halifax.—Mr. Harry Piers, Stanyan.
" Mr. Johnstone MacKay, 32 Morris Street.
Musquodoboit Harbor.—Rev. James Rosborough.
Port Hawkesbury.—Mrs. Louise Paint Forsyth.
Pictou.—Mr. Charles B. Robinson, B. A., Academy.
Wallace.—Miss Mary E. Charman.
Amherst.—Grades VIII. and IX., Public Schools.

Prince Edward Island.

Charlottetown.—Mr. John MacSwain, Prin. Public Schools.

New Brunswick.

Grand Harbor.—Mr. Henry F. Perkins, Grand Manaan.
St. Stephen.—Mr. J. Vroom.
St. John.—Students, Victoria High School,
Hammond River.—Miss Edith Darling.
Kingston.—Miss Mary F. McLean.
Richibucto.—Miss Isabella J. Caie.

Ontario.

Niagara Falls Park.—Mr. Roderick Cameron.
Ottawa.—Mr. James Fletcher, F. R. S. C.
Muskoka.—Miss Alice Hollingworth, Beatrice P. O.

MANITOBA.

Winnipeg.—Rev. W. B. Burman, B. D.
" Mr. E. A. Garratt.

ASSINIBOIA.

Pheasant Forks.—Mr. Thomas R. Donnelly.

ALBERTA.

Olds.—Mr. T. N. Willing.

BRITISH COLUMBIA.

Vancouver.—Mr. J. K. Henry, B. A., High School.

FULL LIST OF PHENOMENA ASKED TO BE OBSERVED.

BOTANICAL.

[E. C. & W. mean Eastern, Centre and Western Canada, respectively.]

1. ALDER (*Alnus incana*). Catkins shedding pollen.
2. ASPEN (*Populus tremuloides.*) Catkins shedding pollen.
3. " " " Leafing out.
4. Spring Anemone (*A. patens, var. Nuttalliana.*) Flowering.
5. Red Maple (*Acer rubrum.*) Flowering. (E.)
6. Hepatica (*Hepatica, & H. triloba-acutiloba*). Flowering.
7. Adder's-tongue Lily (*Erythronium Americanum*). Flow'g.
8. Mayflower (*Epigaea repens*). Flowering. (E.)
9. DANDELION (*Taraxacum officinale*). Flowering.
10. Salmon-berry (*Rubus spectabilis*). Flowering. (W.)
11. " " Ripe fruit. (W.)
12. Ash-leaved Maple (*Acer Negundo*). Flowering. (C. & W.)
13. STRAWBERRY (WILD.) (*Fragaria Virginiana & Chilensis*) Fl.
14. " " " " Ripe fruit.
15. Wild Plum (*Prunus Americana*). Flowering. (E.)
16. CHERRY (CULTIVATED). Flowering.
17. " " Ripe Fruit.
18. WILD RED CHERRY (*Prunus Penn. & emarg.*) Flowering.
19. INDIAN PEAR, JUNE-BERRY, (*Amelanchier.*) Flowering.
20. " " (*Amelanchier*). Ripe fruit.
21. BLACKBERRY (*Rubus occidentalis & leucodermis.*) Flow'g.

22. APPLE (CULTIVATED.) Flowering.
23. Western Dog-wood (*Cornus Nuttallii*). True flowers open.
24. OAKS (RED, BLACK or WHITE). Flowering.
25. HAWTHORN (*Crataegus*). Flowering.
26. LILAC (CULTIVATED) (*Syringa vulgaris*). Flowering.
27. RASPBERRY (WILD). First ripe fruit.
28. WHEAT (WINTER). First sowing.
29. " " Flowering.
30. " " Harvest.
31. " (SPRING). First sowing.
32. " " Flowering.
33. " " Harvest.

METEOROLOGICAL.

34. LAST SPRING FROST, date with note explaining particulars.
35. FIRST AUTUMN FROST, " " "
36. OPENING OF LAKES Devoid of Current in SPRING, date.
37. CLOSING " " " FALL, "
38. OPENING OF RIVERS IN SPRING, date.
39. CLOSING OF RIVERS IN FALL, date.
40. NUMBER OF THUNDER STORMS IN YEAR,(with dates of each).
Jan........Feb........March..........Apr........
May ....June...........July ....
.... Aug. ....Sept ....
...........Oct........ Nov ....Dec.........
41. DATES AND DURATIONS OF DROUGHTS AFFECTING VEGETATION.

ZOOLOGICAL.

42. Song Sparrow (*Melospiza fasciata*). First appearance.
43. Sparrow (*M. montana, guttata,* and *rufina*). First app.
44. Robin (*Merula migratorius*). (E. & C.)
45. " (*M. propinqua*). (W.)
46. Blue Bird (*Sialia sialis*). (E. & C.)
47. " (*S. arctica and Mexicana*). (C. & W.)
48. Junco, slate colored snow-bird (*J. hiemalis*). (E. & C.)
49. " (*J. annectens* and *Oregonus*). (W.)
50. RED-WINGED BLACKBIRD (*Agelaius Phoeniceus*).

51. Spotted Sandpiper (*Actitis macularia*).
52. Swallow (*Tachycineta bicolor*).
53. Meadowlark (*Sturnella magna*). (E.)
54. Kingfisher (*Ceryle Alcyon*).
55. Hummingbird (*Trochilus colubris*). (E. & C.)
56. " (*T. rufus and Calliope*). (W.)
57. Nighthawk (*Chordeiles Virginianus*). (E. & C.)
58. " (*C. Henryi*). (W.)
59. Wild Ducks, First birds.
60. " First flock.
61. " Flocks migrating south.
62. " Last birds.
63. Wild Geese, First birds.
64. " First flocks.
65. " Flocks migrating southward.
66. " Last birds.
67. First date at which "Frogs" are heard whistling.

TABLE A.

PHENOLOGICAL OBSERVATIONS, CANADA, YEAR 1895.

Number.	Last day of Jan., 31 of year. " " Feb., 59 " " " Mar., 90 " " " Apl., 120 " " " May, 151 " " " June, 181 " " " July, 212 " " " Aug., 243 " " " Sep., 273 " " " Oct., 304 " " " Nov., 334 "	Yarmouth, F.	Yarmouth, L.	Berwick.	Halifax, P.	Halifax, M.	Musquodoboit Harbor.	Average, South Nova Scotia.	Port Hawkesbury.	Pictou.	Wallace.	Amherst.	Average, North Nova Scotia.
	BOTANICAL.												
1	Alder, pollen	102	...	104	98	...	...	101.1	...	102	111	...	106.5
2	Aspen, pollen	...	...	124	122	...	...	123.0	...	111	113	...	112.0
3	" leaf	...	...	139	143	...	...	141.0	...	131	128	140	133.0
4	Anemone, fl	...	...	...	...	...	...	.....	...	...	...	...	.....
5	Red Maple, fl	125	...	123	126	...	...	124.7	...	126	123	120	123.0
6	Hepatica, fl	...	...	...	...	...	...	.....	...	127	...	...	127.0
7	Ad. T. Lily, fl	...	...	...	...	...	...	.....	...	125	...	...	125.0
8	Mayflower, fl	61	102	105	111	114	112	100.9	125	110	114	116	116.2
7	Dandelion, fl	119	108	129	...	129	130	125.0	126	120	133	124	125.7
10	Salmon-berry, fl	...	...	...	...	...	...	.....	...	...	...	...	.....
11	" fr	...	...	...	...	...	...	.....	...	...	...	...	.....
12	Negundo, fl	...	...	...	...	...	...	.....	...	...	...	...	.....
13	Strawberry, fl	124	129	126	124	130	134	127.9	134	129	130	124	129.2
14	" fr	...	158	159	159	156	...	158.0	179	161	...	154	164.6
15	Wild Plum, fl	...	...	...	...	...	...	.....	...	...	...	...	.....
16	Cherry (Cult.), fl	...	150	131	136	...	...	139.0	144	133	133	127	134.2
17	" " fr	...	...	...	...	...	...	.....	193	...	187	...	190.0
18	Wild Red Cherry, fl.	145	151	132	143	144	139	142.3	...	136	135	141	134.0
19	Indian Pear, fl	144	...	128	134	137	...	135.7	157	131	...	135	141.0
20	" " fr	...	...	...	...	...	...	.....	196	178	...	...	187.0
21	Blackberry, fl	169	...	163	164	...	...	165.3	172	164	...	...	168.0
22	Apple, fl.	133	156	143	149	...	150	146.2	150	139	131	145	141.2
23	Western Dogwood, fl.	...	...	...	...	...	...	.....	...	...	...	...	.....
24	Oaks, fl	...	...	142	156	...	...	149.0	...	130	...	...	130.0
25	Hawthorn, fl	161	...	148	160	...	161	157.5	...	140	...	...	140.0
26	Lilac, fl	161	159	147	152	153	161	155.5	156	147	...	...	151.5
27	Raspberry, fr	169	185	180	197	...	...	182.7	196	...	...	...	196.0
31	Spring Sowing, 1st	...	...	...	...	...	...	.....	...	...	...	...	.....
33	" Harvest, 1st.	...	...	...	...	...	...	.....	...	...	...	...	.....

TABLE A.—*Continued.*

PHENOLOGICAL OBSERVATIONS, CANADA, YEAR 1895.

Number.	Charlottetown.	Grand Harbor.	St. Stephens.	St. John.	Hammond River.	Kingston.	Richibucto.	Average, New Brunswick.	Niagara Falls.	Ottawa.	Muskoka.	Average, Ontario.	Winnipeg, B.	Winnipeg, G.	Pheasant Forks.	Olds, Alberta.	Average, Central Provinces.	Vancouver.
1	124	108	103	110	...	...	...	107.0	107	105	111	107.7	...	...	...	...	....	61
2	128	...	...	...	...	...	...	....	...	102	114	108.0	114	105	...	111	110.0	...
3	...	...	124	...	...	...	124	124.0	...	...	...	....	130	121	...	122	124.3	...
4	...	...	...	131	...	...	...	131.0	121	...	...	121.0	100	102	105	97	101.0	...
5	...	130	118	119	...	...	126	123.2	111	109	126	115.3	...	...	...	...	....	...
6	...	...	...	124	...	...	...	124.0	109	...	128	118.5	...	...	...	...	....	...
7	...	...	...	124	120	...	...	122.0	111	...	114	112.5	...	...	...	...	....	...
8	125	...	...	118	...	122	112	117.3	...	...	...	....	...	...	...	...	....	...
9	139	126	127	...	130	139	132	131.0	111	...	126	118.5	123	123	...	143	129.7	99
10	...	...	...	...	...	...	...	....	...	...	...	....	...	...	...	...	....	82
11	...	...	...	...	...	...	...	....	...	...	...	....	...	...	...	...	....	154
12	...	...	...	...	...	...	...	....	127	119	...	123.0	112	105	...	...	108.5	...
13	139	124	128	124	117	142	126	126.8	...	...	126	126.0	128	130	...	136	131.3	110
14	...	163	157	171	...	...	166	164.2	...	...	165	165.0	158	166	...	172	165.3	159
15	...	...	...	...	...	...	...	....	139	...	135	137.0	...	...	...	...	....	...
16	...	...	135	...	...	...	143	139.0	124	...	...	124	...	...	...	...	....	112
17	...	...	...	...	...	...	188	188.0	...	...	...	....	...	...	...	...	....	174
18	145	...	...	138	...	141	...	139.5	...	130	126	128.0	128	...	...	...	128.0	124
19	...	136	130	131	134	...	133	132.8	126	129	126	127.5	130	125	...	137	130.7	...
20	...	...	...	...	...	...	...	....	...	...	...	....	...	...	...	207	207.0	...
21	...	...	...	...	...	...	...	....	...	...	160	160.0	...	...	...	...	....	...
22	...	155	135	...	...	145	145	145.0	129	...	...	129.0	...	128	...	...	128.0	...
23	...	...	...	...	...	...	...	....	...	...	126	126.0	...	145	...	...	145.0	123
24	...	...	...	...	...	...	134	134.0	...	...	...	....	...	127	...	...	127.0	...
25	158	...	...	...	...	149	158	149.5	...	...	139	139.0	140	135	...	...	137.5	146
26	...	...	...	...	...	150	150	150.0	139	136	...	137.5	140	132	...	...	136.0	125
27	...	...	...	...	...	...	...	....	...	...	...	....	...	...	...	...	....	...
31	123	...	...	...	...	128	128	128.0	...	...	...	....	94	95	96	94	94.7	...
33	...	...	...	...	...	...	239	239	...	...	...	....	...	...	234	...	234.0	...

TABLE B.

PHENOLOGICAL OBSERVATIONS, CANADA, YEAR 1895.

Number.	Last day of Jan., 31 of year. " " Feb., 59 " " " Mar. 90 " " " Apl., 120 " " " May, 151 " " " June, 181 " " " July, 212 " " " Aug., 243 " " " Sept., 273 " " " Oct., 304 " " " Nov., 334 "		Yarmouth, F.	Yarmouth, L.	Berwick.	Halifax, P.	Halifax, M.	Musquodoboit Harbor.	Port Hawkesbury.	Pictou.	Wallace.	Amherst.
	METEOROLOGICAL.											
34	Spring frost, last		..	....	....	....	....	..	....	....	....	....
35	Autumn " first		..	....	259	284	.. .	..	....	294	276	283
36	Lakes open............		..	....	....	110	....	.	....	110	....	110
37	Lakes close............		..	....	....	....	....	..	....	....	....	347
38	Rivers open.......		..	....	....	....	....	.	....	110	....	....
39	Rivers close............		..	....	....	....	....	..	....	....	....	103
40	Thunderstorms	Jan. .	..	....	....	....	....	..	....	22	...	....
		April	..	115	115	115	115	..	....	110 119	....	....
		May .	..	150	....	....	....	..	138	130	130 131	130 150
		June.	..	....	....	....	....	..	179	....	....	....
		July .	..	207	....	188 197 207	....	.. .. ..	.... 196	....	....	 206
		Aug .	..	230	230	216 230 236	....	.. .. ..	....	....	226 232 233	 233
		Sept .	.	254 269	268	269	....	..	273	....	....	269
		Oct ..	.	....	....	301	....	.	278	298	298	298
		Nov..	..	308	....	....	....	..	....	....	....	....
		Dec. .	..	336	....	....	....	..	....	....	....	....
41	Droughts		.. ..	....	....	....	....		152 177 182 197	....	.. ..	157 170 182 197

TABLE B.—*Continued.*

PHENOLOGICAL OBSERVATIONS, CANADA, YEAR 1895.

Number.	Charlottetown.	Grand Harbor.	St. Stephens.	St. John.	Hammond River.	Kingston.	Richibucto.	Niagara Falls.	Ottawa.	Muskoka.	Winnipeg, B.	Winnipeg, G.	Pheasant Forks.	Olds, Alberta.	Vancouver.
34	120	....	....	....	....	154	154	141	....	141	....	147	159	164	..
35	272	....	288	....	...	257	257	....	....	234	....	251	227	226	..
36	....	....	....	....	....	....	....	....	....	116	....	....	....	....	..
37	....	....	....	....	...	....	....	....	...	....	....	....	....	....	..
38	109	....	98	....	....	....	100	....	....	....	....	97	91	....	..
39	6	....	....	....	....	....	342	....	....	....	....	302	305	....	.
40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..
	....	....	100	....	....	....	....	....	....	....	91	....	....	....	..
	123	....	....	....	....	....	123	....	....	124	....	....	....	....	..
	151	....	150	....	....	....	128	....	....	131	123	...	....	146	..
							150	....	....	147	...	....	....	....	..
										....	....	....	....	156	..
										....	....	...	....	161	..
										154	....	....	....	162	..
										163	166	....	....	163	..
	153	....	165	....	....	....	163	....	..	165	173	....	....	164	..
							165	....	..	173	....	....	....	166	..
										177	....	....	....	168	..
										....	....	....	....	170	..
										....	...	....	....	174	..
							203	....	....	189	....	....	....	183	..
	....	....	....	...	....	..	204	....	....	193	....	....	181	194	..
	204	....	....	....	....	..	206	....	....	202	186	...	190	200	..
	....	....	....	....	....	..	207	....	....	....	....	....	200	206	..
							208	....	....	....	....	....	212	207	..
							....	....	....	....	....	...	....	209	..
							220	....	....	218	....	....	....	215	..
	220	....	....	....	....	..	226	...	...	223	....	....	....	224	..
	229	....	....	....	....	..	233	....	....	229	225	....	....	232	..
	233	....	....	....	....	.	....	....	....	....	....	....	....	233	..
							....	....	....	....	....	....	....	234	..
							....	....	....	....	....	....	...	236	..
														252	..
	269	....	....	....	....	....	260	....	....	254	245	....	..	254	..
														259	..
	298	...	....	....	....	....	298	....	....	....	....	....	....	....	.
	....	...	....	....	....	....	....	....	...	....	....	....	....	....	.
	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..
41	....	....	....	....	....	..	165								..
	...	....	....	....	....	..	173	....	..	177	....	....	....	....	..
	....	....	....	....	....	..	209	....	..	189	....	....	....	....	..
	....	....	....	....	....	..	216	....							

TABLE C.

PHENOLOGICAL OBSERVATIONS, CANADA, YEAR 1895.

Number.	Last day of Jan., 31 of year. " " Feb., 59 " " " Mar., 90 " " " Apl., 120 " " " May, 151 " " " June, 181 " " " July, 212 " " " Aug., 243 " " " Sept., 273 " " " Oct., 304 " " " Nov., 334 "	Yarmouth, F.	Yarmouth, L.	Berwick.	Halifax, P.	Halifax, M.	Musquodoboit Harbor.	Average, South Nova Scotia.	Port Hawkesbury.	Pictou.	Wallace.	Amherst.	Average, North Nova Scotia.
	ZOOLOGICAL.												
42	Song Sparrow, arrived.	..	..	97	92	97	..	95.3	98	..	..	..	98.0
43	Mt " "	..	..	..	..	..	..	....	..	..	..	..	....
44	Robin, "	..	..	94	94	97	..	95.0	95	105	..	111	103.6
45	Western Robin, "	..	.	..	..	..	..	....	..	..	..	..	....
46	Blue Bird, "	..	..	..	..	..	..	....	..	..	..	..	....
47	Western B. Bird, "	..	.	..	..	..	..	....	..	..	..	..	....
48	Junco, "	..	..	102	100	..	..	101.0	..	..	..	..	....
49	Western Junco, "	..	.	..	.	..	.	....	..	..	..	..	....
50	Red-Winged B. B. "		..	..	..	..	..	....	..	..	..	..	....
51	Sandpiper, "	..	..	122	149	..	..	135.5	..	.	..	..	....
52	Swallow, "	.	..	127	112	..	..	119.5	..	..	132	..	132.0
53	Meadowlark, "	..	..	..	..	..	..	....	..	..	..	..	....
54	Kingfisher, "	..	..	128	127	..	..	127.5	..	..	.	..	....
55	Hummingbird, "	..	..	137	144	..	.	140.5	140	124	..	138	134.0
56	Western H. B., "	..	..	..	..	..	..	....	..	.	..	..	....
57	Night Hawk, "	.	..	147	153	..	.	150.0	182	..	..	110	146.0
58	Western N. H., "	..	..	..	..	..	.	....	..	..	..	..	....
59	Wild Duck, 1st B.....	..	..	..	..	..	..	....	..	..	..	76	76.0
60	" 1st Fl ...	..	..	84	56	..	..	70.0	..	.	..	111	111.0
61	" Fl. S....	..	..	..	..	.	..	....	..	..	..	..	....
62	" B. S.....	..	..	..	..	..	.	....	..	..	.	..	....
63	Wild Geese, 1st B....	..	..	.	.	..	..	....	..	..	..	..	....
64	" 1st Fl....	..	.	..	71	..	..	71.0	..	..	..	85	85.0
65	" Fl. S....	..	..	..	..	..	..	...	..	..	..	305	305.0
66	" B. S.....	..	..	..	.	.	.	....	..	..	..	334	334.0
67	Frogs Whistle	..	109	..	110	113	..	110.6	..	111	..	110	110.5

TABLE C.—*Continued.*

PHENOLOGICAL OBSERVATIONS, CANADA, YEAR 1895.

Number.	Charlottetown.	Grand Harbor.	St. Stephens.	St. John.	Hammond River.	Kingston.	Richibucto.	Average, New Brunswick.	Niagara Falls.	Ottawa.	Muskoka.	Average, Ontario.	Winnipeg, B.	Winnipeg, G.	Pheasant Forks.	Olds, Alberta.	Average, Central Provinces.	Vancouver.
42	97	82	..	..	..	..	..	82.0	83	..	..	83.0	..	..	..	..	..	..
43	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	91	91.0	..
44	103	81	98	..	..	108	98	96.2	91	..	93	92.0	..	..	..	..	..	..
45	..	..	..	..	..	..	..	..	..	..	..	..	96	110	100	91	99.2	..
46	..	..	..	..	..	..	..	..	97	..	..	97.0	..	..	..	..	..	..
47	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	92	92.0	..
48	103	W	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
49	..	..	..	..	..	..	..	..	..	..	..	..	94	..	..	..	94.0	..
50	..	..	..	..	..	..	..	..	106	..	..	106.0	102	..	95	..	97.5	..
51	145	..	..	..	..	..	..	..	123	..	..	123.0	..	..	..	..	..	..
52	132	108	..	..	..	..	112	110.0	..	..	..	..	123	123	..	..	123.0	..
53	..	..	..	..	..	..	..	..	111	..	..	111.0	101	..	94	..	97.5	..
54	..	..	..	..	..	..	116	116.0	91	..	..	91.0	..	..	..	..	..	..
55	..	..	..	..	..	..	138	138.0	128	..	..	128.0	..	..	..	..	..	..
56	..	..	..	..	..	..	..	..	..	..	..	..	..	..	221	..	..	..
57	203	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
58	..	..	..	..	..	..	..	..	..	..	..	..	..	127	146	..	136.5	..
59	..	W	..	..	..	..	..	..	83	..	..	83.0	89	..	88	86	87.7	..
60	110	..	..	..	..	..	..	..	83	..	..	83.0	95	..	92	..	93.5	..
61	..	..	..	..	..	277	..	277.0	..	..	..	..	..	..	..	..	..	..
62	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	323	323.0	..
63	76	..	..	..	..	98	..	98.0	83	..	..	83.0	79	..	79	..	79.0	..
64	85	85	96	..	..	103	..	94.6	83	..	..	83.0	91	127	90	90	99.5	..
65	260	..	..	..	..	..	..	..	..	..	..	..	280	..	..	314	297.0	..
66	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
67	113	..	..	..	..	117	123	120.0	102	..	111	106.5	95	90	98	..	94.3	53

"W" above = winters.

It will be noticed that the averages of some phenomena in northern Nova Scotia appear to be more advanced than in the southern stations this year. Last year it was noticed that, taking ten common plants, the average season in the south was over eight days earlier than in the north. Whether this announcement stimulated the northern observers to be more constantly watchful than usual in the interests of their climate, or whether it is to be accounted for otherwise, there need not be the slightest suspicion that any of the observers, who are well known to me, put a single figure down in the "interest of any particular climate." They may have made a greater effort to get at the exact facts, which would tend to bring phenomena more promptly to their notice.

The following table shows another manner of treating these statistics, in order to draw general inferences, which were the figures exactly true and the stations fairly arranged, must be correct:

Average Date of Flowering of TEN *Common Plants, at the Stations in Nova Scotia, in 1892, 1893, 1894, and 1895.*

NAME.	1892.	1893.	1894.	1895.	Average of these years.
Early Spring Flowers.					
Mayflower	98	108	104.7	108.5	104.8
Aspen	131	123	122.2	117.5	123.4
Red Maple	123	130	126.3	123.9	125.8
Strawberry	129	133	131.6	123.5	130.5
Late Spring Flowers.					
Cherry (Cult)	146	142	146.3	136.6	142.7
Indian Pear	145	144	146.0	138.3	143.3
Cherry (Wild)	150	144	147.0	138.1	144.8
Apple	146	146	152.1	143.7	146.9
Hawthorn	163	160	160.3	154.0	159.3
Lilac	163	160	162.3	153.5	159.7
Average date of the *ten* plants	139.4	139.0	139.9	134.3	138.1
Days, season in advance (+), or behind (-) on the average, taking the *ten* plants.	1 - .3	-0.9	-1.8	+3.8	

Taking these ten plants whose times of flowering range from April to June, it will be seen that the spring season of 1895 was, in Nova Scotia, nearly *four* (3.8) days in advance of the average for the four years, while that of 1894 was nearly *two* (1.8) days behind. But, dividing the spring season into two divisions, before and after the middle of May, the first *four* plants belong to early spring and the last *six* to late spring. The average dates of blooming, and the differences from the average of the four years, are shown in the following table:

	1892.	1893.	1894.	1895.	Average.
First *four* plants above .. (Early Spring Fl.)	120.2 +0.9	123.5 -2.4	121.2 -0.1	119.6 +1.5	121.1
Last *six* plants above .... (Late Spring Fl.)	152.2 -2.7	149.3 +0.2	152.3 -2.8	144.0 +5.5	149.5

This means, that the early spring of 1892 was nearly a day, (0.9), in advance of the average, but the late spring was retarded nearly three (2.7) days. Was the latter part of May in 1892, colder than the average? And so forth with the other items.

X. Preliminary Notes on the Orthoptera of Nova Scotia. By Harry Piers.

(Read 13th April, 1896.)

The order Orthoptera, which includes the cockroaches, crickets, grasshoppers, locusts, earwigs, etc., may be defined as a group of insects having mouth parts formed for biting, an incomplete metamorphosis, and four wings, the first pair thickened, the second pair thin and folded into longitudinal plaits when at rest.

The species of this order are mostly common and well-known ; and as many of them are very destructive to vegetation, their study is of much economic importance. In the United States, extensive reports have been made upon the more harmful kinds, and the question of how to keep them in check has been carefully considered by many experts.

With the exception of incidental notes in Walker's list of Canadian species,* the Orthoptera of Nova Scotia have received no attention from naturalists. During the past year (1895) and occasionally in former seasons, I have given some attention to their collection and study, and I now present a few preliminary notes on the species which have so far come to my notice. I hope to devote some years to their study, and will, I trust, at a future time be able to give a full account of our species. It is probable that the Orthopterous fauna of this province does not embrace a great many species, but future collecting will reveal the presence of a number which have not come under my observation during the time I have already devoted to the order.

The Orthoptera of Nova Scotia, as far as observed by me, represent four families, viz., (1) the Blattidæ or cockroaches, of which two species (introduced) are recorded in the following pages, and one or more other species will doubtless be found

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* *Vide* Hemiptera, Heteroptera and Dermaptera (Orthoptera) of America to the north of the United States. By Francis Walker, F. L. S., London, England. *Canadian Entomologist*, vol. iv., 1872, pp. 29-31.

under stones and the bark of stumps; (2) the Gryllidæ or crickets, two species reported; (3) the Locustidæ or grasshoppers, two species reported; (4) the Acrididæ or locusts, eight species. Of the remaining North American families—the Forticulidæ or earwigs, the Mantidæ or praying mantes, and the Phasmidæ or walking-sticks—I have so far met no specimens.

I am under obligations to Dr. Samuel H. Scudder, of Cambridge, Massachusetts, the best authority upon North American Orthoptera, and also to William Beutenmüller, Esq., Curator of the Department of Entomology, American Museum of Natural History, New York, for examining specimens and thus checking my own determinations. The nomenclature of my paper follows in the main that of Mr. Beutenmüller's "Descriptive Catalogue of the Orthoptera found within fifty miles of New York City" (*Bulletin American Museum of Natural History*, vol. vi., 1894, pp. 253-316.)

BLATTIDÆ.

Phyllodromia germanica (Linnæus).

Croton Bug; German Cockroach.

This species, which is a native of Europe, made its appearance in New York at the time the Croton aqueduct was built. It is very abundant in some houses in Halifax, and is locally known by the name "Yankee Settler." It is a small species, about 16 mm. in length, and is of a yellowish brown colour, with two dark-brown longitudiual stripes on the thorax. Warm places, such as the vicinity of fire-places and hot-water pipes, are most attractive to it; and it is said to be particularly destructive in buildings heated by steam. It is less likely to be found in filthy surroundings than the oriental cockroach. The great rapidity with which it breeds, and its small size, which permits it easily to hide itself in cracks, make the species one of the worst insect pests in cities. Dr. Riley was of the opinion that Persian insect powder was the best means of stopping the inroads of this roach. The species is less strictly nocturnal than *S. orientalis*.

Stylopyga orientalis (Linnæus).

Oriental Cockroach; Black Beetle.

This large, dark-brown roach is a native of Asia, but it has been carried by shipping to all parts of the world. It is common in Halifax, and delights in damp, dirty places. The intoduction and continual burning of electric lights in our city bakeries, has done much to rid such places of these pests, for they have a great aversion to light. Bakers tell me that they largely use powdered borax for keeping them in check. Infested places should be kept clean, dry, and light.

GRYLLIDÆ.

Gryllus pennsylvanicus, form *neglectus*, Scudder.

On September 4th, 1892, I observed immense numbers of these large crickets in the grass of King's Meadow, near King's College, Windsor, N. S. They were in company with *Nemobius fasciatus vittatus*, but far outnumbered the latter. The extreme timidity which characterizes the species was cast aside and they only moved from an approaching foot when it threatened to trample upon them. They were still numerous when I left Windsor at the end of September. Seven alcoholic specimens, six females and one male, were preserved. The species seems to be rare about Halifax. On September 2nd, 1896, I obtained two specimens on Bedford Rifle Range, where they are probably not uncommon; and another was taken at Halifax on October 10th.

It may be mentioned that the nomenclature of the Gryllidæ has been very unsettled and the study of the family is consequently attended with much difficulty. *Gryllus luctuosus*, *G. nigra*, and *G. neglectus*, which were formerly considered as species, have recently been regarded as merely forms of *G. pennsylvanicus.*

Nemobius fasciatus, form *vittatus* (Harris).

Wingless Striped Cricket.

This well-known small cricket is exceedingly abundant in fields about Halifax. I have also found it very common at

Windsor, and it is probably as plentiful all over the province. Its notes are one of the most familiar sounds of autumn, and are heard both during the day and night. The stridulation is produced by lifting the wing-covers about 45° above the abdomen and then shuffling them together, producing a sound resembling the word *plee-e-e-e*, *plee-e-e-e*, *plee-e-e-e*, or *cree-e-e-e*, etc. It has been suggested that these notes can be reproduced by taking a silver half-dollar between the fingers and striking the coin with the edge of a nickle. These autumnal sounds ring continually in our ears until the first frosts put a stop to the love-making. During recent years the shrilling of this species has been first noted on the following dates: August 19th, 1890; August 6th, 1891; July 29th, 1892 (at Windsor, N. S.); August 2nd, 1893; July 29th, 1895; August 11th, 1896. By October 31st of last year, only two or three individuals could be heard, and by November 6th, a lovely, warm, Indian summer day, on listening at one place, only about one individual could be detected—in fact the species was all but silent. None were noted after that date, although a few individuals might have been found two or three days later.

I have not observed the form *fasciatus* in Nova Scotia.

Scudderia pistillata, Brunner.

The general colour of this insect, as found in Nova Scotia, is a pale oil-green or apple-green; upper part of eye, brown; region between base of antennæ, centre of face, and labium, white; a cream-buff stripe on each dorso-lateral part of the thorax; beneath, whitish-green; white between the legs and on the throat, and two longitudinal white lines, slightly raised, on the ventral surface of the abdomen; soles of feet and antennæ light brownish. Length of head and body, exclusive of abdominal appendages, 22 mm.

This handsome Katydid is very common about Halifax. It is found upon the foliage of bushes, chiefly alders, in or near swampy places. Although so plentiful, yet its protective similitude to a leaf, both in colour and form, and its usual slow move-

ments, make it very difficult to detect. Attention is chiefly directed to it by the loud stridulation of the males at nightfall. During the day they are usually silent, or at rare intervals produce a short, sharp note, *zip*. After dark, however, they make the swamps resound with their loud calls, and we then become aware of their abundance. On close examination at such a time, the males—usually only one on each bush—may be seen walking very slowly over the leaves and twigs. Occasionally they suddenly slightly lift and part the wing-covers and close them again, thereby producing a sharp *zip* or *crick*, not very loud—this being the note which is usually heard during daylight. After making this sound at irregular intervals for some time, the wing-covers are opened to a greater extent, and are then again closed, producing a long-drawn, exceedingly loud *cr-r-r-r-r-r-r-ick*. This is repeated in couplets several times in succession. This challenging cry is immediately answered by one after another of its neighbouring fellows, until numbers are rasping out their ear-piercing notes, as notable a rural chorus as that of the Tree Toads. Gradually the sounds become few, but after a short interval they are again frequent. This note is doubtless the loudest produced by any of the Orthoptera I have yet heard in the province. It can be partially produced by moving the wing-covers of a captive or dead individual. The note bears little or no resemblance to that of its famous relative, the broad-winged Katydid (*Cyrtophyllus concavus*) of the Central and Eastern States. Our species, as I have before observed, is usually very slothful. Occasionally, however, in daytime, and doubtless also at night, they fly some distance from tree to tree. One noted on September 28th, while it was attempting to cross a road, made only short flights, and usually fell on its side when it came to the ground. It, however, easily flew to and lighted upon a fence rail. Usually the insect can be readily captured with the fingers while it clings to a leaf. Occasionally, on a near approach to the bush upon which it rests, it will drop suddenly a foot or two to a branch beneath. I have not yet succeeded in detecting the female, although I have carefully

searched at night with a lantern. There is a female, however, among some Orthoptera collected by Mr. G. Marshall in the eastern part of Annapolis County. I have noted the species as late as October 17th, (1895). This insect has not heretofore been reported from Canada.

Xiphidium fasciatum (De Geer).

Slender Meadow Grasshopper.

This fragile, apple-green species, with a long, straight ovipositor, is very common about Halifax, and I have also collected specimens on the meadows at Windsor. The species has a very wide range, perhaps the widest of any of the North American Locustidæ, being found, according to Redtenbacher, from Canada to Buenos Ayres. It frequents damp situations, and numbers were observed among the rank marsh grass on Marsh Lake, at Sackville, N. S., on September 3rd, 1895. The last individual noted in 1895 was seen on September 10th. Females are observed much more frequently than males. The stridulation of this grasshopper is rather weak. One observed in September produced a song which may be represented thus, *plee-e-e-e-e-e-e-e-e-e-e-e, tcit, tcit, tcit, tcit.* This was produced by rapidly vibrating the tegmina for the first note, *plee,* and doing the same at intervals for the remaining ones, *tcit,* (imitated by suddenly drawing in the breath, with the tongue applied to the roof of the mouth).

ACRIDIDÆ.

Stenobothrus curtipennis (Harris).

Short-winged Locust.

Abundant in Nova Scotia among grass in meadows. Both the green and the more sober coloured varieties are found. The species is easily known by its short tegmina. Its stridulation is frequently heard in the country, and hündreds rise from about the feet when walking through short grass. The last individuals of 1895 were noted on October 19th. Several were seen on October 25th, 1896.

Camnula pellucida, Scudder.

Clear-winged or Pellucid Locust.

This sober-coloured insect occurs from Connecticut northward, and has been reported from Quebec (Provancher) and is common at Montreal (Caulfield). I have so far obtained but two specimens, both females. The first was captured, September 5th, 1895, in company with *Circotettix verruculatus* in a stony place near Block-house Pond, Halifax. The second was taken October 2nd, in a damp, grassy spot on the side of the road, close to Cow Bay Bridge. When upon the ground, the species somewhat resembles *C. verruculatus.*

Dissosteria carolina (Linnæus).

Carolina Locust.

This locust is widely distributed, being found from the Atlantic to the Pacific, and in the United States as well as in Canada. It is the largest acridian occurring in Nova Scotia. It frequents dry stony places and roadsides, and resembles in colour the prevailing tint of the situation in which it occurs. It is much less abundant than *C. verruculatus* which is found in the same situations. The last individual noted in 1895 was seen on September 28th.

Circotettix verruculatus (Kirby).

Very common in dry, warm stony places, in company with the less abundant species, *D. carolina.* During flight it produces a loud cracking or clapping sound, which is familiar to all and very suggestive of hot and dusty country roads. Although resembling, when on the ground, the larger *D. carolina*, it may be readily distinguished when in flight—the basal portion of the wing being yellow in *verruculatus*, whereas in *carolina* it is black and the outer edge of the wing is yellow. In 1895 the last specimen of *verruculatus* was taken on September 28th. It appears about the end of July.* Six specimens of this insect are among some Orthoptera collected by Mr. Marshall in the

* In 1895, it was first noted on July 18th, and it was common on the 25th.

eastern part of Annapolis County, and it is doubtless found throughout the entire province.

Mecostethus gracilis (Scudder).

A handsome species, apparently rare in this vicinity. Last year I was able to obtain but four specimens, all males. One of these was taken among long grass in a dry situation on the summit of Block-house Hill, Halifax, September 1st, 1895. The remaining three were captured in a damp, grassy place on the side of the road near Cow Bay Bridge, on October 2nd. The stridulating area on the wing of this species is large and prominent, and stridulation may be easily produced in the dead insect by moving the femora against the wings. The species has not hitherto been reported from Canada.

Melanoplus femur-rubrum (De Geer).

Red-legged Locust.

This excellent flyer is common in Halifax County. It was also noted on the diked meadows about Windsor, and without doubt is abundant throughout the entire province. It is generally pistributed over Canada and the United States, occurring from the Atlantic to the Pacific and south to Central America. It is said to occur, however, only at certain suitable localities within its limits, a favourable amount of humidity being the chief climatic condition required. The species is closely related to the very destructive Rocky Mountain Locust *(M. spretus)*—the most terrible insect pest in America. It seldom, however, exhibits the migratory habits of the latter. *Femur-rubrum* no doubt does much damage throughout Nova Scotia, devouring field crops and other vegetation, and it should be destroyed whenever possible. The species was noted up to October 20th, 1895.

Melanoplus atlanis (Riley).

Lesser Migratory Locust.

Apparently not common about Halifax, but at present very abundant on Sable Island. Next to *M. spretus* of the Western United States, this is the most destructive locust of North America, and the question of how to protect the country from

its ravages, has occupied the attention of all agriculturists and economic entomologists. It occurs from 53° north latitude or even nearly to the Arctic circle, to the north of Mexico, and from ocean to ocean. With *femur-rubrum* it has, perhaps, a greater range than any other species of North American Acrididæ. To an unpracticed eye, it can be easily mistaken for the less destructive *femur-rubrum*, from which it has only of recent years been separated by the late Prof. Riley. To distinguish it, a minute examination of the last abdominal segment and the cerci of the male is necessary. The former is *notched* in the present species, and the latter are of uniform width and rounded at the end, instead of tapering as in *femur-rubrum*. The females are very difficult to distinguish, these differences being inapplicable to that sex.

Although I have examined hundreds of specimens of *femur-rubrum* collected about Halifax during the past summer, yet I have found but few of the present species. A male was taken on August 29th in a dry field, two more were taken in short, poor grass on Camp Hill, September 28th, and another was captured at Cow Bay, October 2nd. I think it probable, however, that it will be found more frequently in such situations as Camp Hill.

Last fall the Marine and Fisheries Department gave me some locusts that had been taken on Sable Island, off the coast of Nova Scotia, on September 23rd, 1894. Upon examination they proved to be *M. atlanis*, one male and three females. I was told that these insects had suddenly become a frightfnl scourge upon the island, insomuch as to demand attention from the authorities in charge. Mr. R. J. Boutilier, superintendent of the place, informs me that up to about 1891, he had neither seen nor heard of any locusts upon the island. About that time, however, they made their appearance, and since then have increased at an appalling rate. So destructive did they become, that in 1894 it was only possible to cut one load of hay at a place where fourteen loads had previously been obtained. They seem to attack the grass near the root, and unless kept in check they will ultimately destroy what little vegetation there is upon the

place. This would be a serious matter, for the sod prevents the sand from being shifted by the winds. Should the grass become destroyed, nothing could prevent the island from ultimately disappearing beneath the sea, in which case this dreaded spot would become a hundredfold more dangerous to shipping.

Last year, 1895, these pests were more numerous than ever, and it was necessary to import a quantity of hay for the purpose of supporting the ponies, which were suffering from want of grass. It also became necessary to send to the mainland more of these animals than is usual, in order to reduce the stock which had to be fed. I am told that the insects could be swept in bucketsful from the doorsteps, and I have the superintendent's positive assurance that they even entered the half-closed window of an unused room and ate considerable portions of a cotton blind, a piece of which was sent to me. No means have been taken to keep them in check, and the probability is that during the coming summer the plague will be worse than ever.*

Thinking that possibly there might be more than one species upon the island, I asked Mr. Boutilier to send me, upon his return, a larger number of the insects, and particularly any which appeared to differ from those already examined. In November I received a pint bottle full of locusts preserved in alcohol. All were *atlanis*, mostly females. Mr. Boutilier informed me that upon his return to the island on October 12th, he found that many of the insects had disappeared owing to the lateness of the season, and at the time he wrote (November 10th) they were all dead, although in 1894 they had survived very cold weather if not frost. So far, he said, the season had been very mild with no frost.

It therefore cannot be doubted that *Melanoplus atlanis* is responsible for all the extraordinary damage upon the island. Their sudden appearance in a place previously without such insects, and so many miles from the mainland, is most remark-

* In a letter dated May 28th, 1896, received since the preparation of the above paper, Mr. Boutilier writes as follows: "The locusts are with us again, but are a month later than last year. The season, however, is that much late—very cold and backward, and vegetation is greatly retarded. The young have appeared as yet only at the east end of the island, whereas they were much more plentiful at the west end last year."

able. It is possible that they may originally have been taken to the island in small quantities of hay used for packing—for no cargoes of hay were then imported; or perhaps the eggs had been introduced in some earth which may have coated vegetables. This, however, is unlikely to account for their sudden appearance in large numbers. Upon informing Dr. Scudder of the matter, he said he had no doubt that the insects had flown to the island, their powers of flight being great when aided by an advantageous wind.* The scarcity of natural enemies has since greatly favoured their rapid increase.

The introduction of a number of turkeys would, I think, be the best means of destroying the invaders, if it were possible to protect the birds from animals which might prey upon them. Perhaps some of the locust-killing appliances used in the United States might be employed in the present instance with advantage. The matter seems to demand immediate attention.

Melanoplus femoratus (Burmeister).

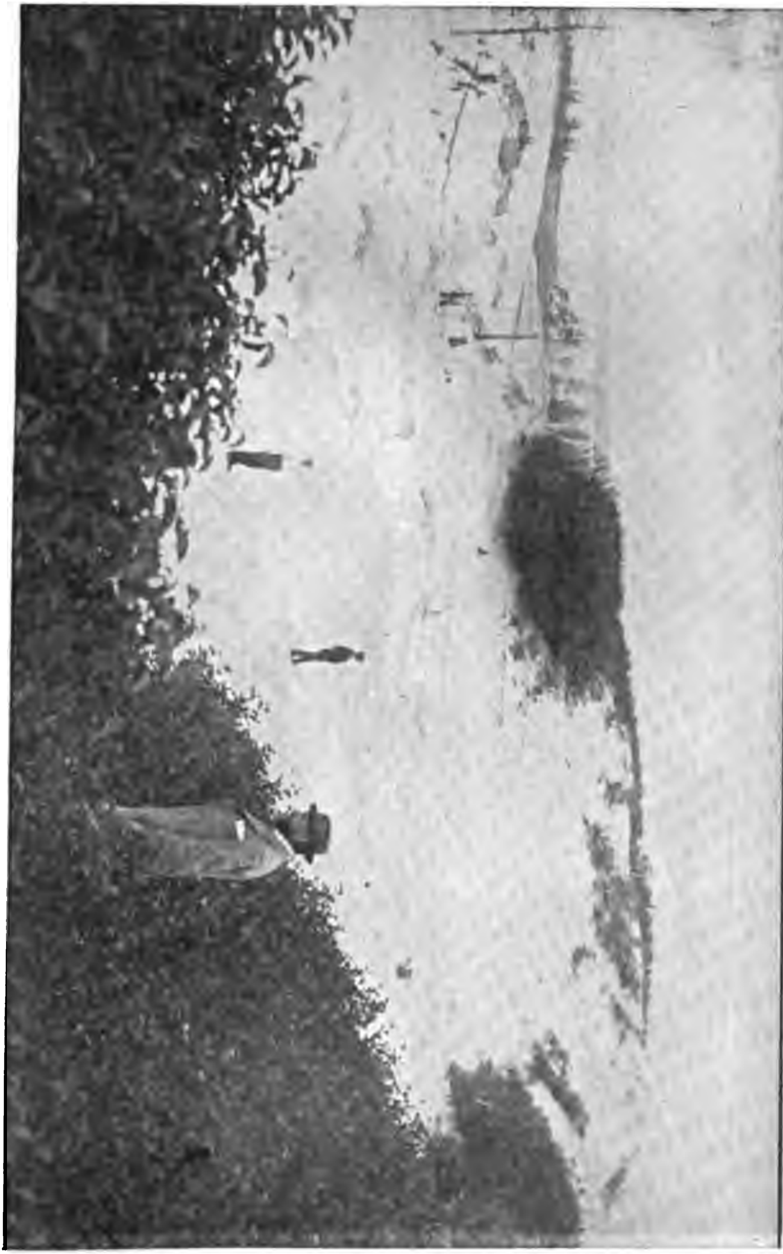
Yellow-striped Locust.

This insect is familiar to everyone, and its distinctive colouring makes it impossible to confound it with any other locust found in this locality. It is one of the most abundant species in the county of Halifax, and is also without doubt as common in all other parts of the province, probably doing much damage wherever it occurs. It is common in long grass in meadows, and seems very fond of the rank vegetation which grows on the skirts of fields. I have also frequently observed it in marsh grass. The last individual was noted in 1895 on October 20th. Should it be found advisable to keep this pest in check, the destruction of weed patches and the plowing of waste spots in the vicinity of field borders, etc., as recommended in the United States, would probably keep down its numbers and render it capable of doing little injury.

This species has a very extensive range, being found from Nova Scotia to British Columbia, and from Hudson's Bay south nearly to the Ohio and North Carolina.

* Sable Island is one hundred miles from the mainland. There are no intervening islands.

Proc. and Trans. N.S. I.S.; Vol IX., Part 2; date of publication, Oct. 31st, 1896.



DRIFT SAND HILLS, BARRINGTON BAY, N. S

Illustrating Prof. Bailey's Paper: "*On Illustrations of Dynamical Geology.*"

INNER SLOPE OF DRIFT SAND HILLS, BARRINGTON BAY, N. S.

Illustrating Prof. Bailey's Paper: "*On Illustrations of Dynamical Geology.*"

GLACIAL TROUGH IN TILTED CAMBRIAN QUARTZITES, LOCKEPORT ISLAND, N. S.

Illustrating Prof. Bailey's Paper: "*On Illustrations of Dynamical Geology.*"

MEMBERS of the Institute, and Societies in correspondence with it, would confer a great favor if they would send to the Council, for distribution to Scientific Institutions whose sets of the Institute's publications are incomplete, any duplicate or other spare copies which they may possess of back numbers of its Proceedings and Transactions. They should be addressed: *The Secretary of the N. S. Institute of Science, Halifax, Nova Scotia.*

THE attention of members of the Institute is directed to the following recommendations of the Committee of the British Association on Zoological Bibliography and Publication:—

"That authors' separate copies should not be distributed privately before the paper has been published in the regular manner

"That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible.

"That new species should be properly diagnosed and figured when possible.

"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules for quotation, such as that recently adopted by the French Zoological Society."

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1896-97.

I.—On the Relation of the Physical Properties of Aqueous Solutions to their State of Ionization.—By Professor J. G. MacGregor, *Dalhousie College, Halifax, N. S.*

(Communicated 14th December, 1896.)

It has often been pointed out that, according to the dissociation or ionization conception of the constitution of a solution of an electrolyte, the difference between the physical properties of one in which ionization is complete and those of the solvent must be compounded additively of the differences produced by the two ions. It would seem to be equally obvious that, in the case of solutions in which the ionization is not complete, the differences referred to must be similarly compounded of those produced by the undissociated molecules and by the free ions; and if so, it should be possible to express the numerical values of the various properties in terms of the state of ionization. Such an expression would take its simplest form in the case of solutions so dilute that the molecules, dissociated or undissociated, might be regarded as sufficiently far apart to render mutual action between them impossible, and in these circumstances the change produced in the properties of the solvent by the undissociated and the dissociated molecules respectively might be expected to be simply proportional to their respective numbers per unit of volume. It is the object of this paper to

test the applicability to sufficiently dilute solutions, of such an expression, viz.,

$$P = P_w + k(1-\alpha)n + l\alpha n, \qquad (1)$$

where P is the numerical value of any property (density, &c.), P_w that of the same property of water under the same physical conditions, n the molecular concentration of the solution, *i. e.*, the number of gramme-equivalents of the dissolved substance per unit volume of the solution, α the ionization-coefficient αn and $(1-\alpha)n$ consequently the numbers of dissociated and undissociated gramme-equivalents per unit of volume respectively, and k and l constants, which may be spoken of as ionization-constants, which will vary with the solvent, the substance dissolved, the property to which they apply, the temperature, and the pressure, but not with the concentration of the solution.

The formula can obviously apply only to properties for which P_w has a finite value. Thus it is inapplicable to electrical resistance, for which P_w would have a practically infinite value.

SIMPLE SOLUTIONS.

In order to test the applicability of the above expression I have determined the ionization-constants for the density, thermal expansion, viscosity, surface-tension, and refractive index of solutions of Sodium and Potassium Chlorides, by the aid of observations made by Bender *, Brückner †, and Rother ‡. I selected these observations as a first instalment, not because of their precision (for in one or two cases more exact observations are available), but because these observers, in all cases but one, determined the values of the above properties for mixtures of solutions as well as for simple solutions. I selected the above chlorides partly because I thought it well to begin with salts of simple molecular structure, but largely also because, for the purpose of calculating the conductivity of mixtures of them (as described in my paper on this subject §), I had already obtained interpolation formulæ and curves which, judged by the results

* Wied. *Ann.* vol. xxii. (1884) p. 184, and vol. xxxix. (1890) p. 89.

† *Ibid.* vol. xlii. (1891) p. 293. ‡ *Ibid.* vol. xxi. (1884) p. 576.

§ Trans. N. S. Inst. Sci. ix. (1896) p. 101; and Phil. Mag. [5] xli. (1896) p. 276.

of that paper, gave with considerable accuracy the ionization-coefficients of the simple solutions of these salts in terms of their molecular concentration. To save space I may tabulate here the values of the ionization-coefficients used in the calculations for simple solutions. They are as follows:—

SODIUM CHLORIDE.		POTASSIUM CHLORIDE.	
Grm.-mols. per litre.	Ionization-coefficient at 18° C.	Grm.mols. per litre.	Ionization-coefficient at 18° C.
·25	·792	·1875	·8267
·5	·736	·3402	·811
·8928	·6866	·375	·796
1·0	·676	·5	·788
1·5	·633	·6856	·769
1·8353	·601	·75	·768
2·0	·5866	1·0	·756
2·5	·5504	1·0467	·755
2·8373	·5255	1·4292	·731
3·0	·514	1·5	·731
3·9375	·4516	2·0	·712
		2·185	·7048
		2·5	·695
		2·986	·681
		3·0	·680

These coefficients were obtained from Kohlrausch and Grotrian's and Kohlrausch's observations of conductivity at 18° C.* In obtaining them I took the specific molecular conductivity (referred to mercury) at infinite dilution to be 1216×10^{-8} for KCl, and 1028×10^{-8} for NaCl, not being aware at the time that Kohlrausch had given 1220 and 1030 respectively as more exact values. Nevertheless, to save labor, I have used the above values of α in the calculations of this paper, having satisfied myself by a re-calculation in one case that no appreciable difference in the results would be produced by the employment of more exact values. It will be noticed that in one or two cases the above values of α are obviously a little out; but they would seem to be sufficiently accurate for my purpose. I did not foresee the extent of the calculations,

* Wied. *Ann.* vi. (1879) p. 37, and xxvi. (1885) p. 195.

or I should have determined all the values of α required at the outset, and checked them by comparison with one another.

I have determined the ionization-constants (k and l) in all cases in which more than two observations of a property on solutions of sufficient dilution were available, by the method of least squares. The constants thus determined and used in the calculations are tabulated below. In all cases the available observations had been made on solutions of such great concentration that the values of the constants obtained cannot be regarded as exact; but the calculations may serve as a test of the general applicability of the expression referred to above. The only available observations, as far as I know, on solutions of sufficient dilution for the determination of the ionization-constants and the limits of concentration within which the above expression is applicable, are those by Kohlrausch and Hallwachs* on the specific gravity of dilute solutions, from which two of my students have undertaken to determine the density-constants for the salts and acids examined.

With regard to the observations which I used in determining the various ionization-constants, the following statements should be made:—

Bender's determinations of density (*i. e.* specific gravity referred to water at 4° C.) were made at 15° C., but were readily reduced to 18° by the aid of his observations on the thermal expansion between 15° and 20° of the same solutions. According to his statement, the fourth place of decimals in his values may be in error by ±2 or ±3. The density of water was taken to be 0·99863.

Bender's determinations of thermal expansion are for the interval between 15° and 20° C., and will therefore be sufficiently nearly proportional to the coefficients of expansion at 18° for my purpose. He considers that they may be in error by ±2 in the sixth place of decimals. On plotting his observations, however, it becomes obvious that they do not all attain this degree

* Wied. *Ann.* liii. (1894) p. 14.

of accuracy. The expansion of water was taken, according to his observations, to be $0 \cdot 0_3 878$ for the same interval.

Brückner's observations of viscosity were made at 15° C.; but he gives an interpolation formula, applicable between 15° and 20°, by means of which at least approximate values for 18° were obtained. His values for water at 15° and 20° do not agree well with those given by Landolt and Börnstein. I have therefore taken 0·010613 as the viscosity at 18° of the water used by him, a value which has to his value at 15° the same ratio as Landolt and Börnstein's for the same temperatures. The actual concentrations of Brückner's solutions differed from those given in the tables below by about 0·1 per cent.; but so small a difference could produce no appreciable error in the result. He gives as his "mean probable error of observation," $\pm 2 \cdot 4$ in the fifth place of decimals for sodium-chloride solutions, and $\pm 1 \cdot 8$ for those of potassium chloride.

Rother's observations of surface-tension were made at 15° and are therefore not precisely comparable with calculated values based on the values of ionization-coefficients for 18°. From Kohlrausch's data,* however, it would appear that between 15° and 18° in the case of potassium-chloride solutions containing 0·5 and 3 gramme-molecules per litre, the ionization-coefficient changes only by about 0·13 and 1·3 per cent. respectively; and in the case of sodium-chloride solutions of the same concentrations only by about 0·4 and 0·6 per cent. respectively. For the more dilute solutions, therefore, my calculations will be practically comparable with Rother's observations. He seems to regard his determinations as possibly in error by ± 5 to 8 in the the third place of decimals. The surface-tension of the water he used he found to be 7·357.

Bender's observations of refractive index were made at 15° C., but were reduced to 18° by means of data provided in his paper, based on observations made by Fouqué†. The refractive index of the water he used he found to be 1·33310

* Wied. *Ann.* xxvi. (1885) p. 223.
† *Compt. Rend.* lxiv. (1867) p. 121.

Sodium Chloride Solutions.				Potassium Chloride Solutions.			
Grm.-mols. per litre.	Observed Value.	Calc. Value.	Difference.	Grm.-mols. per litre.	Observed Value.	Calc. Value.	Difference.
DENSITY (BENDER'S OBSERVATIONS).							
0.25	1.00898	1.00916	$+0.0_318$	0.1875	1.00752	1.00731	-0.0_321
0.5	1.01930	1.01929	− 01	0.375	1 01567	1.01586	+ 19
1.0	1.03925	1.03910	− 15	0.75	1.03317	1.03278	− 39
1.5	1.05834	1.05842	+ 08	1.0	1.04362	1.04401	+ 39
2.0	1.07772	1.07701	− 71	1.5	1.06630	1.06621	− 09
2.5	1.09633	1.09532	-0.0_2101	2.0	1.08767	1.08823	+ 56
				2.5	1.10755	1.11008	$+0.0_2253$
				3.0	1.13057	1.13177	+ 120
THERMAL EXPANSION (BENDER'S OBSERVATIONS).							
0.25	.001013	.001022	$+0.0_59$	0.1875	.000963	000966	$+0.0_403$
0.5	.001141	.001141	± 0	0.375	.001037	.001040	+ 03
1.0	.001357	.001349	− 8	0.75	.001183	.001173	− 10
1.5	.001522	.001526	+ 4	1.0	.001249	.001255	+ 06
2.0	.001663	.001657	− 6	1.5	.001395	.001395	± 00
2.5	.001776	.001769	− 7	2.0	.001500	.001517	+ 17
3	.001876	.001848	-0.0_428	2.5	.001580	.001621	+ 41
VISCOSITY (BRÜCKNER'S OBSERVATIONS).							
0.5	.010988	.010978	-0.0_410	0.5	.010457	.010451	-0.0_406
1.0	.011480	.011475	− 05	1.0	.010395	.010379	− 16
1.5	.012048	.012047	− 01	1.5	.010351	.010366	+ 15
2.0	.012707	.012730	+ 23	2.0	.010394	.010393	− 01
2.5	.013472	.013458	− 14	2.5	.010444	.010457	+ 13
3.0	.014373	.014267	-0.0_3106	3.0	.010566	.010555	− 11
SURFACE-TENSION (ROTHER'S OBSERVATIONS).							
0.8928	7.482	7.482	±0.000	0.3402	7.411	7.408	−0.003
1.8353	7.629	7.629	± 0	0.6856	7 460	7.462	+ 2
2.8373	7.780	7.798	+ 18	1.0467	7.518	7.519	+ 1
3.9375	7.954	7.997	+ 43	1.4292	7.584	7.583	− 1
				2.1851	7.705	7.709	+ 4
				2.9859	7 844	7.846	+ 2
REFRACTIVE INDEX, D LINE (BENDER'S OBSERVATIONS).							
0.5	1.33824	1.33824	$\pm 0.0_300$	0.5	1.33803	1.33806	$+0.0_303$
1.0	1 34307	1.34306	− 01	1.0	1.34278	1.34274	− 04
1.5	1 34770	1.34770	± 00	1.5	1.34721	1.34722	+ 01
2.0	1.35213	1.35206	− 07	2.0	1.35179	1.35158	− 21
2.5	1.35673	1.35632	− 41	2.5	1.35623	1.35582	− 41

at 18° for the D line. He seems to regard his observations as possibly in error by ±1 in the fourth decimal place.

The tables on page 224 contain the results of the calculations of the values of the physical properties mentioned, with both the observed values on which the determination of the constants was based, and a few additional observed values for stronger solutions.

The following comments may be made on these tables:

Density.—NaCl. The first four observations were used in determining the constants; and up to a concentration of 1·5 the differences are within the limits of experimental error, and show a satisfactory alternation of sign.—KCl. The first five observations were used. The differences are large, but the alternation of sign shows that the expression is applicable. On plotting Bender's values they are readily seen not to lie on a smooth curve.

Thermal Expansion.—NaCl. The first four observations were used. The differences up to a concentration of 2·5 are probably within the limits of experimental error, and their alternation of sign is satisfactory.—KCl. The first five observations were used. The differences are not so satisfactory as in the case of the sodium salt either as to magnitude or sign; but on plotting the observations the third is seen to be somewhat out; and it is obviously to this observation that the defective agreement is due.

Viscosity.—NaCl. The first five observations were used. The differences are within the limits of error, but the signs are not satisfactory. The fourth observation, however, appears to be defective. Mützel*, in applying a formula for viscosity in terms of density and concentration to these observations, found also that this observation was out. It is worth noting, also, that Mützel found his formula, which expressed the increase of viscosity due to the salt in solution on the assumption that the only action occurring was between salt and water, was applicable

* Wied. *Ann.* xliii. (1891) p. 35.

to only the first five of the above observations. To represent the viscosity of stronger solutions he had to introduce a term expressing the effect due to the mutual action of the molecules of salt.—KCl. All six observations were used. The agreement in this case is quite satisfactory.

Surface-Tension.— NaCl. Only two observations on sufficiently dilute solutions were available, and the applicability of the formula cannot therefore be tested. The constants were found, for use in the calculation of the surface-tension of mixtures.—KCl. The first four observations were used, and the agreement is quite satisfactory up to a concentration of 3 grm.-mols. per litre.

Refractive Index.—In the case of both salts the first three observations were used, and in both the agreement is quite satisfactory up to a concentration of about 2 grm.-mols. per litre.

The above tables seem to be at any rate quite consistent with the possibility of expressing the values of at least five of the physical properties of moderately dilute solutions in terms of their state of ionization. I hope to find leisure at an early date to extend the investigation to solutions of salts and acids of a more complex character and to other properties.

The following are the ionization-constants used in the above calculations:—

	SODIUM CHLORIDE.		POTASSIUM CHLORIDE.	
	k.	*l.*	*k.*	*l.*
Density	+ ·030841	+ ·045079	+ ·03543	+ ·048591
Thermal Expansion.	− ·0001445	+ ·0007658	− ·000614	+ ·00069685
Viscosity	+ ·002347	+ ·0001504	+ ·001904	− ·0009247
Surface-Tension	+ ·20574	+ ·11001	+ ·24249	+ ·126806
Refractive Index...	+ ·006318	+ ·011713	+ ·0027853	+ ·011853

These constants are obtained from solutions of too great concentration to be regarded as exact values. Nevertheless it may be admissible, tentatively, at least, and so far as these two salts are concerned, to draw the following conclusions:—Undissociated and dissociated molecules are nearly equally effective in increasing the density,—those dissociated, however, being somewhat the more effective of the two. (2) Undissociated molecules diminish the thermal expansion, those dissociated increasing it to a greater extent. (3) In the case of viscosity it is the undissociated molecules which have the preponderating influence, those dissociated having but a slight effect, which may be an increasing or a diminishing effect. Thus Arrhenius's expectation that all dissociated ions would be found to diminish viscosity seems to be only partially realized, though possibly from observations on more dilute solutions, both l's might be found to be negative. (4) In the increase of surface-tension the undissociated molecules have about twice as great an influence as the dissociated. (5) In increasing the refractive index it is the dissociated molecules which have the preponderating influence; and their superiority is greater in increasing the refractive power than increasing the density.

MIXTURES OF SOLUTIONS.

For a solution containing several salts, 1, 2, etc., the value of a property, according to the conception under consideration, will be:—

$$P = P_w + k_1(1 - a_1)n_1 + l_1 a_1 n_1 + k_2(1 - a_2)n_2 + l_2 a_2 n_2 + \&c., \quad . \quad (2)$$

the n's being numbers of gramme-equivalents per unit volume o the solution. If the solution have been formed by the mixture of the volumes v_1 and v_2 of two simple solutions of salts, having one ion in common, for which, before the mixing, the property had the values:—

$$\left.\begin{aligned} P_1 &= P_w + k_1(1 - a_1)n_1 + l_1 a_1 n_1, \\ P_2 &= P_w + k_2(1 - a_2)n_2 + l_2 a_2 n_2, \end{aligned}\right\} \quad . \quad . \quad (3)$$

then, since on mixing, the state of ionization will, in general,

change, we shall have as the value of the property for the mixture, assuming no change of volume on mixing,

$$P=P_w+(k_1(1-a_1')n_1+l_1a_1'n_1)\frac{v_1}{v_1+v_2}+(k_2(1-a_2')n_2+l_2a_2'n_2)\frac{v_2}{v_1+v_2}, \quad (4)$$

the n's being numbers of gramme-equivalents per unit volume of the original simple solutions, and α_1' and α_2' being the ionization-coefficients in the mixture As the values of the k's and l's have been determined above for sodium and potassium chloride for a number of properties, and, as I have shown in my paper on the "Conductivity of Mixtures," cited above, how the ionization-coefficients after mixing may be determined, it should be possible to predict the values of these properties for mixtures of solutions of these salts.

The following tables show that this can be done. The ionization-coefficients were determined in the way described in the paper referred to. The constants k and l employed in the calculations were those determined above. The observations were made by the authors whose determinations for simple solutions were used above; in fact in most cases it was the solutions of the tables given above which were mixed. The limits of experimental error are thus of about the magnitudes mentioned above in each case. All remarks made above with regard to the reduction of observations to 18° C., the values of the property for water, etc., apply also to the mixtures. In all cases, except that of surface-tension, the solutions mixed were mixed in equal volumes. Unfortunately, Bender made no observations on the refracting power of mixtures.

Constituent Solutions (grm.-mols. per litre.)		Ionization Coefficients in Mixture.		Observed Value.	Calculated Value.	Difference.
NaCl.	KCl.	NaCl.	KCl.			
DENSITY (BENDER'S OBSERVATIONS).						
1·0	0.1875	.7268	.7720	1.02358	1.02350	$-0.0_{3}08$
"	0.375	.714	.7625	1.02785	1.02766	− 19
"	0.75	.688	.7629	1.03641	1.03600	− 41
"	1.0	.6728	.7632	1.04139	1.04158	+ 19
"	1.5	.6494	.7478	1.05293	1.05263	$-0.0_{3}30$
"	3.0	.6143	.7283	1.08580	1.08595	+ 15
THERMAL EXPANSION (BENDER'S OBSERVATIONS).						
1.0	0.1875	.7268	.7720	.001174	.001174	$\pm 0.0_{4}00$
"	0.375	.714	.7625	.001208	.001203	− 05
"	0.75	.688	.7629	.001275	.001264	− 11
"	1.0	.6728	.7632	.001297	.001305	+ 08
"	1.5	.6494	.7478	.001376	.001376	± 00
"	3	.6143	.7283	.001543	.001596	+ 53
VISCOSITY (BRÜCKNER'S OBSERVATIONS).						
1.0	0.5	.7059	.7635	.010940	.010947	$+0.0_{4}07$
"	1.0	.6728	.7632	.010918	.010920	+ 02
"	1.5	.6494	.7478	.010876	.010915	+ 39
"	2.0	.6143	.7283	.010890	.010956	+ 66

SURFACE TENSION (ROTHER'S OBSERVATIONS).

Constituent Solutions.				Ionization Coefficients in Mixture.		Observed Value.	Calculated Value.	Difference.
Concentration (grm.-mols. per litre).		Volume (litres.)						
NaCl.	KCl.	NaCl.	KCl.	NaCl.	KCl.			
0.8862	0.6836	0.14487	0.14545	0.6906	0.7632	7.477	7.472	− 0.005
1.8109	1.411	0.13993	0.14096	0.6087	0.7279	7.607	7.602	− 5
0.8824	2.1822	0.14489	0.13659	0.6123	0.7311	7.600	7.591	− 9
2.8406	0.6862	0.13511	0.14544	0.6027	0.7298	7.622	7.616	− 6
1.8155	2.9887	0.13996	0.13241	0.5185	0.7125	7.734	7.810	+ 76

It will be noticed that in the case of the third mixture of the density and thermal expansion series (the same mixture) the differences are comparatively large; but it is obvious from the data of the fourth column in these series that the ionization-coefficients have not been accurately determined for mixtures of about the concentration of the one referred to. With these exceptions the agreement between observed and calculated values is satisfactory, the differences being either well within, or at worst on, the limit of observational error, up to mean concentrations of about 1.5. The determination of the ionization-coefficients was especially difficult in the case of the surface-tension observations, because Rother mixed equal weights of his simple solutions, not equal volumes. Nevertheless, in all except the strongest of these mixtures, the differences are probably not beyond the limits of experimental error. Obviously, alternation of sign is not to be expected in these calculations.

RELATIVE VALUES OF A PROPERTY FOR A MIXTURE AND FOR ITS CONSTITUENTS: "CORRESPONDING" SOLUTIONS.

As change of ionization in general occurs on mixing two solutions, it follows from (3) and (4) that the value of a property for a mixture of two solutions having one common ion will differ from the volume-mean, $(v_1 P_1 + v_2 P_2)/(v_1 + v_2)$, of its values for the constituents by the amount

$$(l_1 - k_1)\frac{n_1 v_1}{v_1 + v_2}(a_1' - a_1) + (l_2 - k_2)\frac{n_2 v_2}{v_1 + v_2}(a_2' - a_2) \quad \ldots\ldots\ldots \quad \ldots(5)$$

The name of "corresponding" solutions has been given to solutions for which this quantity vanishes. In general it will obviously have a value, though that value may be small.

In most cases this conclusion is borne out by experience. But Rother has concluded from his observations that, in the case of surface-tension, throughout a wide range of concentration, solutions of all concentrations are "corresponding." Were this the case it would throw serious doubt on the possibility of expressing surface-tension in terms of state of ionization. If,

however, with the aid of the constants for surface-tension determined above, we compute, in the case of Sodium and Potassium Chlorides, the difference between the value for a mixture and the volume-mean of the values for its constituents, we find it to be beyond the limit of Rother's power of observation. Thus, in the case of his first mixture calculated above, the difference amounts to only $0.0_3 15$. His conclusion should thus have been that the difference, if any, between the surface-tension of a mixture and the volume-mean of those of its constituents was within the limits of his experimental error. He might even have concluded, however, that there was probably such a difference in the case of Sodium and Potassium Chlorides; for in all the mixtures of solutions of these salts which he examined, the volume-mean of the values for the constituent solutions were found to be less than the values for the mixtures.

The above expression (5) will vanish if the constituents of the mixture are isohydric, *i. e.*, have states of ionization which do not change in the mixing; and it will vanish in that case, whatever the values of the other quantities involved in the expression may be. When the constituents are not isohydric the condition of its vanishing will be

$$\frac{n_1}{n_2} = \frac{(l_2 - k_2)(a_2' - a_2)v_2}{(l_1 - k_1)(a_1 - a_1')v_1} \qquad \text{(6)}$$

It is obviously improbable that in any case in which this condition may be fulfilled the numbers of gramme-equivalents per litre in the constituent solutions will have a simple relation, such as 1 : 2, 4 : 3, &c.

The conclusions drawn by Bender and Brückner from their observations on density, thermal expansion, electrical conductivity, and viscosity, viz., that there is such a simple relation in the case of all "corresponding" solutions, so far as the properties mentioned are concerned, is thus inconsistent with the possibility of expressing the values of these properties in terms of the state of ionization.

Both Bender* and Brückner† obtained their results from numerous series of observations, in each of which a solution of given concentration of one salt was mixed in succession, in equal volumes, with a number of solutions of different concentrations of a second salt having one ion in common with the first. The values of the property under consideration were determined both for the simple solutions and for the mixtures, and the arithmetic means of the values for the constituents of the several mixtures were found. Curves were then plotted with molecular concentrations of the simple solutions of the second salt as abscissæ, and the observed values for the mixtures and the arithmetic means of the values for the constituents, respectively, as ordinates. The "corresponding" solutions were indicated by the points of intersection or contact of these curves. In all cases the two curves for each series are found to run very close together, so close that it is impossible to determine exactly at what points they touch or cross; and when the observational errors admitted by the authors are taken into account, they must be considered to be within touching or crossing distance at considerable distances on each side of the points at which Bender and Brückner assumed them to be contact or to intersect. I have plotted a number of these curves so as to indicate accurately all significant figures, and have found, on taking possible errors of observation into account, that in no case can a more definite conclusion be drawn than that "corresponding" solutions have pretty nearly the simple relations as to concentration claimed by the authors. It is not necessary to enter into details; but I may, by way of illustration, give the following:—

* Wied. *Ann.* xxii. (1884) p. 184, and xxxix. (1890) p. 89.

† *Ibid.* xlii. (1891) p. 293.

Molecular Concentrations of Corresponding and Isohydric Solutions.

NaCl.	KCl.		
	Values between which curves may be in contact.	Value assigned by Observer.	Isohydric Solution.
CONDUCTIVITY (BENDER'S OBSERVATIONS).			
0.5	0—1.0	0.375	0.47
1	0—1.1	0.75	0.89
2	1.2—1.5	1.5	1.60
3	1.8—2.55	2.25	2.20
4	2.6—3.15	3.0	2.57
VISCOSITY (BRÜCKNER'S OBSERVATIONS).			
1	0.5 —1.9	1.0	1.2
2	1.25—2.5	2.0	2.6

The fourth column of the above table gives approximate values of the concentration of the solutions of KCl (obtained from Kohlrausch's data) which are isohydric with the solutions of NaCl in the first column; and it will be noticed that in most cases these values are within the limits within which Bender's and Brückner's curves must be regarded as being possibly in contact.

It would thus appear that both Bender and Brückner drew too definite conclusions from their observations, and that the observations themselves are not inconsistent with the applicability of expression (1) to the physical properties of solutions.

APPLICATIONS OF THE ASSUMED LAW OF IONIZATION-CONSTANTS. RATIO AND DIFFERENCE OF THE VALUES OF A PROPERTY FOR SOLUTION AND SOLVENT.

If the expression under consideration is applicable to solutions of moderate dilution it should give by deduction the laws which have been found to hold for particular properties of such

solutions, and might be expected to be of use in showing their relation to one another. I need not refer here to the more obvious of such deductions, as, for example, the properties of non-electrolytes, or of electrolytes at extreme dilution, but may restrict myself to cases in which both constants k and l play a part.

The ratio of P to P_w will be

$$\frac{P}{P_w}=1+\frac{k+(l-k)a}{P_w}n.$$

For dilute electrolytes throughout a certain range of concentration, and through a wider range in the case of non-electrolytes, a varies but slightly with n. Throughout such range the coefficient of n in the above expression will thus vary but slightly. Hence, n being small,

$$\frac{P}{P_w}=e^{\frac{k+(l-k)a}{P_w}n}=A^n,$$

approximately, where e is the base of Napier's logarithms and A a constant. Arrhenius,* Reyher† and Wagner‡ have found this result to hold in the case of the viscosity of both classes of solutions.

The difference between P and P_w will be

$$P-P_w=(k+(l-k)a)n.$$

and for the reason just given, will, throughout a certain range of low concentration, wider in the case of non-electrolytes than in that of electrolytes, be approximately proportional to n. This form of the expression obviously includes such laws as Raoult's for vapour tensions, and van 't Hoff's for the depression of the freezing point in non-electrolytes, as well as the approximate proportionality of the rotation of the plane of polarisation to concentration. It has recently been verified by Kohlrausch and Hallwachs's observations on density,§ they having found

* Ztschr. f. phys. Chemie, i, (1887) p. 285.
† Ibid. ii, (1888), p. 753.
‡ Ibid. v, (1890), p. 31.
§ Wied. *Ann.*, liii, (1894), p. 36.

that between concentrations of 0.005 and 1 gramme-equivalent per litre, $(P—P_w)/n$ varies in the case of certain salts and acids only by from 5 to 20 per cent, and in the case of sugar only by 1.5 per cent.

VARIATION OF TEMPERATURE AND OTHER COEFFICIENTS WITH CONCENTRATION.

The temperature-coefficient of any property of a solution of given concentration will be

$$\frac{1}{P}\frac{\delta P}{\delta t}=\frac{\frac{\delta P_w}{\delta t}+\frac{\delta k}{\delta t}n+\left(\frac{\delta l}{\delta t}-\frac{\delta k}{\delta t}\right)an+(l-k)\frac{\delta a}{\delta t}n}{P_w+kn+(l-k)an}\quad\ldots\ldots\ldots\ldots\ldots(7)$$

The pressure-coefficient will have the same form, p being written for t. The concentration-coefficient will be

$$\frac{1}{P}\frac{\delta P}{\delta n}=\frac{k+(l-k)\left(a+\frac{\delta a}{\delta n}n\right)}{P_w+kn+(l--k)an}\quad\ldots\ldots\ \ldots\ldots\ldots\ldots\ldots(8)$$

In the case of a solution of a given salt of given concentration, temperature, and pressure, α, n, and α's rates of change have definite values the same for all properties. For moderately dilute solutions, $\delta\alpha/\delta t$, $\delta\alpha/\delta p$*, and $\delta\alpha/\delta n$ are all small, and $\delta\alpha/\delta t$ and $\delta\alpha/\delta n$ at least have the same sign. Also the k's and l's for the different properties all depend upon the mutual action between molecules and solvent, and may thus be expected to have more or less closely related values. We may therefore expect not only that the coefficients of one kind for the various properties of solutions of a given salt will vary with concentration in a somewhat similar manner, but also that the variation with concentration of all the coefficients, but especially the temperature and pressure-coefficients, will exhibit a certain family likeness. It is obviously not to be expected that the variation will be exactly similar in any case.

This family likeness has been observed in the case of the temperature-coefficients for electrical conductivity and fluidity

* I have not seen Röntgen's paper, on which the statement that $\delta\alpha/\delta p$ is small is based. The *Fortschritte der Physik* reports Tammann as quoting him to that effect.

by Grotrian*, who found that, in general, with increasing concentration both of these temperature-coefficients undergo changes in the same sense. Grossmann† claimed to have proved these coefficients to be equal; but afterwards withdrew the claim as based on an error‡. Kohlrausch and Hallwachs also have noticed for very dilute solutions a close similarity between the curves representing the density and the conductivity respectively of the same salt as functions of the concentration.

The following tables show that this family likeness extends, to a greater or less extent, to all the coefficients for at any rate a considerable number of the properties of solutions. The tables include some of Grotrian's coefficients with others calculated from the observations of Kohlrausch, Bender, Brückner, Rother, Röntgen and Schneider§, Fink ||, and Timberg ¶. The coefficients are in almost all cases mean values, the ranges of temperature, &c., to which they apply, though the smallest for which data are available, being not in all cases the same. As I wish to show only a general similarity, it is not necessary to specify the ranges. The temperatures, &c., of the lower limits of the ranges are also not in general exactly the same. The data of the tables are thus not exactly comparable; but they are sufficiently so for my purpose. The heading n stands for gramme-equivalents per litre.

* Wied. *Ann.* viii. (1879) p. 552.

† *Ibid.* xviii. (1883) p. 119.

‡ See Kohlrausch, Wied. *Ann.* xxvi. (1885) p. 224.

§ Wied. *Ann.* xxix. (1886) p. 194.

|| *Ibid.* xxvi. (1885) p. 505.

¶ *Ibid.* xxx. (1887) p. 545.

SODIUM CHLORIDE SOLUTIONS.

Temperature Coefficients for						Pressure Coefficients for				Concentration Coefficients for							
Conductivity.		Fluidity.		Density.		Conductivity.		Density.		Conductivity.		Fluidity.		Density.		Surface Tension.	
n.	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coeff.
.883	.0218	1.441	.0245	1.	$-.0_3271$	.170	$.0_4801$	.712	$.0_4429$	.5	1.67	.5	—.0895	.5	.0394	.895	.0209
1.828	.0215	2.694	.0243	1.5	$-.0_3304$	.882	$.0_4600$	1.496	$.0_4394$	1	0.639	1.5	—.1081	1.5	.0368	1.835	.0198
2.839	.0213	4.655	.0252	2.	$-.0_3333$	1.828	$.0_4491$	2 651	$.0_4352$	3	0.122	3.	—.1532	3	.0314	2.837	.0203
3.918	.0217			2.5	$-.0_3355$	2.806	$.0_4381$	3.941	$.0_4313$							3.937	.0243
5.078	.0228			3.	$-.0_3375$	3.835	$.0_4083$	5.420	$.0_4277$								
						5.059	$-.0_4110$										
						5.421	$-.0_4142$										

BARIUM CHLORIDE SOLUTIONS.

Temperature Coefficients for						Concentration Coeffts. for	
Conductivity.		Fluidity.		Density.		Conductivity.	
n.	Coeff.	*n.*	Coeff.	*n.*	Coeff.	*n.*	Coefficient.
.501	.0215	.781	.0240	1.	$-.0_3258$	.5	1.629
1.051	.0207	1.704	.0226	1.5	$-.0_3290$	1.0	.610
1.652	.0201	2.945	.0222	2.	$-.0_3318$		
2.314	.0196			2.5	$-.0_3341$		
2.895	.0193			3.	$-.0_3361$		

CALCIUM CHLORIDE SOLUTIONS.

Temperature Coefficients for Surface Tension.	
n.	Coefficient.
About 6.4	$-.0_2134$
" 10	$-.0_2179$

A glance at these tables shows that if regard be had to sign, Grotrian's conclusion as to the temperature-coefficients for conductivity and fluidity applies to all the coefficients for all the properties tested. A given change in the concentration produces a change in the coefficients in the same sense. Too much importance, however, must not be attached to this; for it is obvious that if we should tabulate, say, the coefficients for conductivity, surface tension, viscosity (instead of fluidity) and specific volume (instead of density), it would be found that the changes produced in the first two are in the opposite sense to those produced in the last two. It is interesting, however, to note that the expectation suggested by the above formulæ is distinctly realized.

At very great dilution of electrolytes, the temperature-coefficient becomes, approximately,

$$\frac{1}{P}\frac{\delta P}{\delta t}=\left(\frac{\delta P_w}{\delta t}+n\frac{\delta l}{\delta t}\right)/(P_w+nl), \quad \ldots\ldots\ldots\ (9)$$

the pressure-coefficient having the same form. The concentration-coefficient becomes

$$\frac{1}{P}\frac{\delta P}{\delta n}=l/P_w+nl) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (10)$$

If we compare (9) and (10) with (7) and (8), it becomes obvious that the variation with concentration of the temperature and pressure coefficients will probably be more closely related at low than at high concentrations, but that the opposite will be true of the concentration coefficients. Accordingly, having plotted Grotian's coefficients and those of the above tables as functions of the concentration, I find that the temperature coefficient curves, for any one substance in solution, are in general more closely similar at low than at high concentrations; but that this is not the case for the concentration coefficient curves. In the case of the pressure coefficients the data are insufficient.

A corresponding similarity holds for the absorption spectra of solutions though it cannot be expressed in coefficients. In a former paper * I have shewn that for all solutions for which

* Trans. Roy. Soc. Can., ix (1891), sec. 3, p. 27.

data were available, the absorption spectra were similarly affected by elevation of temperature and increase of concentration.

THE OCCASIONAL CONSTANCY IN THE DIFFERENCE BETWEEN THE MOLECULAR VALUES OF PROPERTIES OF SOLUTIONS HAVING THE SAME MOLECULAR CONCENTRATION.

The difference between the values per gramme-equivalent of any property for two simple solutions, 1 and 2, of different electrolytes but of the same concentration, will be

$$(P_1 - P_2)/n = k_1 - k_2 + (l_1 - k_1)\,a_1 - (l_2 - k_2)\,a_2 \quad \ldots\ldots\ldots (11)$$

Now α in all cases diminishes as n increases. Provided therefore, the values of the $(l-k)$'s have the same sign, and the rates of change of the α's with concentration are inversely proportional, or approximately so, to the $(l-k)$'s of their respective solutions, we shall have $(P_1 - P_2)/n$ exactly or approximately constant. If we regard $(P_1 - P_2)/n$ as approximately constant when its absolute value changes with n only to a small extent, then the more nearly the $(l-k$'s) and the α's are inversely proportional to one another the more nearly constant will $(P_1 - P_2)/n$ be. If, however, we regard this quantity as constant when its values for different values of n differ from one another by only a small percentage, then the magnitude of the $(l-k)$'s becomes of importance, and we may have $(P_1 - P_2)/n$ approximately constant, even though the $(l-k)$'s may be far from being inversely proportional to the α's.

In the case of certain solutions of moderate strength, this approximate constancy of $(P_1 - P_2)/n$ has been observed by Valson and Bender* for the density and the refractive index, by Wagner † for viscosity constants, and by Jahn ‡ for the electro-magnetic rotation of the plane of polarization; and a very close approximation to constancy in the case of the specific

* Wied. *Ann.*, xxxix, (1890), p. 89.

† Ztschr. f. phys. Chemie, v. (1890), p. 31.

‡ Wied. *Ann.*, xliii, (1891), p. 280.

gravities of very dilute solutions is clearly shewn in the results of Kohlrausch and Hallwachs's observations§.

So far as Sodium and Potassium Chlorides are concerned, Bender found that in respect to their density at 15° C.;

For n =	1·0	2·0	3·0
$(P_1 - P_2)/n$ =	$\cdot 0_2 43$	$\cdot 0_2 49$	$\cdot 0_2 51$

The value of $l-k$ for NaCl is +0·01424 and for KCl +0·01316, while a glance at the first table (p. 221) shows that the ionisation coefficient of solutions of the former salt falls off with the concentration somewhat more rapidly than, indeed for some concentrations, about twice as rapidly as, in the case of the latter. There cannot, therefore, be a close approximation to constancy in the absolute values of $(P_1 - P_2)/n$, but as these values are comparatively large, the percentage difference between them is comparatively small.

For the thermal expansion of these salts we have from Bender's observations,

For n =	1	1·5	2	2·5
$(P_1 - P_2)/n$ =	$\cdot 0_3 108$	$\cdot 0_4 85$	$\cdot 0_4 815$	$\cdot 0_4 78$

The value of $l-k$ in this case for NaCl is + $0 \cdot 0_3 91$, and for KCl $+0 \cdot 0_2 13$. There is thus a closer approximation to equality in the values of $(l-k) \Delta\alpha/\Delta n$ for the two salts, for thermal expansion than for density. Accordingly the absolute differences in the values of $(P_1 - P_2)/n$ are smaller than in the case of density. But as the values themselves are much smaller, the differences between the values when expressed as percentages of any one of the values are greater. And thus the approximation to constancy, of $(P_1 - P_2)/n$, in the case of thermal expansion is not so great as in the case of density, when judged in this way.

For viscosity $l-k$ for NaCl is $-0 \cdot 0022$ and for KCl $-0 \cdot 0028$. The values of $(l-k) \Delta\alpha/\Delta n$ will thus be less nearly equal than in the case of the thermal expansion and the

§ Wied. *Ann.*, liii, (1894), p. 14.

differences between the values of $(P_1 - P_2)/n$ will be somewhat greater. As the $(l - k)$'s in this case, however, are more than twice as great as in the case of thermal expansion, the differences in the values of $(P_1 - P_2)/n$, if expressed as percentages of one of them, will be smaller than in the case of thermal expansion. Accordingly we find from Brückner's observations,

For n =	0·5	1·0	1·5	2·0	2·5
$(P_1 - P_2)/n$ =	$\cdot 0_2116$	$\cdot 0_2122$	$\cdot 0_2126$	$\cdot 0_2128$	$\cdot 0_2135$

For surface-tension $l - k$ for NaCl is $-0\cdot096$ and for KCl $-0\cdot116$. The approximation to constancy (judged by the percentage criterion) will thus not be so close as in the last case. Rother's observations give, by graphical interpolation,

For n =	1·0	1·5	2·0
$(P_1 - P_2)/n$ =	·016	·0113	·0105

For refractive index $l - k$ for NaCl is $+0\cdot0054$ and for KCl $+0\cdot0091$. Thus the values of $(l - k)\Delta\alpha/\Delta n$ for the two salts are much more nearly equal than in the case of the other properties and consequently the differences in the values of $(P_1 - P_2)/n$ will be smaller than in the case of the other properties. Bender's observations give for the D line,

For n =	1·0	2·0	3·0
$(P_1 - P_2)/n$ =	$\cdot 0_3 29$	$\cdot 0_3 17$	$\cdot 0_3 24$

If the value for $n = 2$ be omitted from consideration, as being probably in error, $(P_1 - P_2)/n$ is seen to be more nearly constant so far as absolute magnitude is concerned than in the other cases considered. As the values of $(P_1 - P_2)/n$ however, are small, their differences when expressed as percentages are comparatively large, and the approximation to constancy, viewed in this way is less than, *e. g.*, in the case of density.

The above account of this phenomenon may be further tested by the aid of Kohlrausch's observations of electrical conductivity; for in this case $l - k$ is the molecular conductivity at infinite dilution (usually written μ_∞). The

following values of differences of molecular conductivity will be sufficient :

n	$(P_1 - P_2)/n$ FOR CONDUCTIVITY.			
	HCl and NaCl.	HCl and $\frac{1}{2}K_2CO_3$	$\frac{1}{2}H_2SO_4$ and $AgNO_3$	$AgNO_3$ and NaCl.
0·01	2454	2333	1838	+ 55
0·1	2379	2365	1198	+ 21
0·5	2260	2289	1171	− 29
1·0	2085	2120	1185	− 60

Compare with this the following table of values of μ_∞ and α:—

n	IONIZATION-COEFFICIENTS (α).				
	HCl $\mu_\infty = 3500$.	NaCl $\mu_\infty = 1030$.	$\frac{1}{2}K_2CO_3$ $\mu_\infty = 1400$.	$\frac{1}{2}H_2SO_4$. $\mu_\infty = 3700$.	$AgNO_3$. $\mu_\infty = 1090$.
0·01	·976	·934	·773	·772	·933
0·1	·927	·840	·628	·563	·794
0·5	·862	·735	·520	·513	·668
1·0	·794	·675	·471	·492	·582

The approximate constancy holds in the case of HCl and $\frac{1}{2}K_2CO_3$, because μ_∞ for HCl being more than twice as great as for $\frac{1}{2}K_2CO_3$, α for the latter falls off nearly twice as rapidly as for the former. In the case of $AgNO_3$ and NaCl there is no approximation to constancy, because the values of μ_∞ being nearly equal, the rates at which α varies with n are very unequal.

THE INDEPENDENCE OF THE CONTRIBUTIONS MADE TO THE VALUE OF A PROPERTY BY THE FREE IONS.

The constant l for a salt ap will, according to the dissociation conception, be composed additively of two parts, l_a and l_p, pertaining to the ions a and p respectively, and these constants

l_a and l_p will be characteristic of the ions and will not depend upon the salt from which they have been dissociated. A certain amount of evidence has been accumulated which may be said to point in this direction. In the case of several properties it has been shown that for solutions of considerable dilution, the difference between the values of the property for solutions of two salts (*ap* and *bp*) having a common ion and the same molecular concentration, is independent of what the common ion may be; and the value of the difference divided by the number of gramme-equivalents per litre of the salts in solution has been taken to be approximately the difference between the constants l_a and l_b. Results of this kind have been obtained by Valscn and Bender for density and refracting power, by Kohlrausch for electrical conductivity, by Raoult for the depression of the freezing point, by Traube * for the change of volume on solution, by Röntgen and Schneider for compressibility, and by Jahn for the electromagnetic rotation of the plane of polarization.

Applying the above expression, we have for the difference in the values of a property per unit of molecular concentration,

$$(P_{ap}-P_{bp})/n=k_{ap}(1-a_{ap})-k_{bp}(1-a_{bp})+l_p(a_{ap}-a_{bp})+l_a a_{ap}-l_b a_{bp}, \quad (12$$

and at infinite dilution

$$(P_{ap}-P_{bp})/n=l_a-l_b. \quad \ldots\ldots\ldots\ldots \quad (13)$$

Had the experiments referred to been all carried out at extreme dilution, as were those of Kohlrausch, afterwards extended by Loeb and Nernst †, the evidence would be quite satisfactory. But in general they have been made at only moderate dilution, and it is obvious from (12) that the approximate independence of the common ion on the part of $(P_{ap}-P_{bp})/n$, may be quite consistent with considerable variation in l_a-l_b. It is clear that the first three terms of (12) may readily mask any variation in the last two, and that, if the last two did not vary, l_a-l_b could not in all cases be the same.

* *Ztschr. anorgan. Chemie*, iii. (1892), p. 1.
† *Ztschr. für phys. Chemie*, ii. (1888) p. 948.

That no satisfactory conclusion can be drawn from experiments of this kind, unless conducted at extreme dilution, may be shown roughly in the case of density by the aid of the results obtained above. For we may assume that the ionization-constants for density obtained above will not be very different from those which would be derived from observations made at greater dilution*. We know from Kohlrausch and Hallwachs's observations that if ap and bp represent NaCl and $\frac{1}{2}Na_2CO_3$ respectively, $(P_{ap}—P_{bp})/n$ will have the value 0·0139 for solutions containing ·005 grm.-equivalents per litre, and that for NaCl and HCl it will have the value of 0·0235. We may assume that for NaCl and KCl it will be about ·02. From the values of k for these salts we find the first two terms of (12) to be $\cdot 0_3 64$. If we assume l_p to have half the mean value of l for NaCl and KCl, the third term will amount to $—\cdot 0_4 98$. The first three terms thus amount to about $\cdot 0_3 54$, or say 3 per cent. of the value of $(P_{ap}— P_{bp}/n$. Thus, observations of the kind referred to, for density, could give no satisfactory result, even if conducted at this very great dilution. At a dilution of ·001 grm.-molecules per litre, the first three terms of (12), calculated in the same way, amount to $\cdot 0_3 1$, or about 0·5 per cent of $(P_{ap}— P_{bp})/n$. A proved independence of p at this dilution would be more satisfactory.

Observations at such extreme dilutions, in the case of most properties of solutions, are probably impracticable. But they are fortunately unnecessary for the settling of the question under consideration. For if the values of the ionization-constants for any property have been obtained as above from observations over a range extending to great, though not necessarily extreme, dilution, the values so obtained may fairly be assumed to apply very approximately to much greater dilutions; and from the values of l_a+l_p, l_b+l_p, l_a+l_q, l_b+l_q, etc., thus obtained, it may readily be determined whether or not $l_a—l_b$ is independent of the ions p, q, etc. Unfortunately, Kohlrausch and Hallwachs's observations on specific gravity are not sufficiently numerous for this purpose.

* Mr. E. H. Archibald, one of my students, tells me that for magnesium sulphate Kohlrausch and Hallwachs's data give k = ·05663 and l = ·066887.

THE DETERMINATION OF THE IONIZATION-CONSTANTS FOR THE FREE IONS.

The values of the constants l_a, l_b, l_p, etc., may probably, in some cases at least, be determinable in the following way: The experiments just referred to would give $l_a + l_p$, $l_b + l_p$, etc., as well as k_{ap} and k_{bp}, etc. If now, guessing at the value of l_p, we find the first three terms of (12) to be negligible at dilutions at which P_{ab} and P_{bp} can be determined with sufficient accuracy, determination of these quantities will give the value of $l_a\alpha_{ap} - l_b\alpha_{bp}$; and if α_{ap} and α_{bp} be known with sufficient accuracy, l_a, l_b, and l_p may then be found. It would of course be necessary to check our guess at the value of l_p by substituting the value found in expression (12) and seeing whether or not with this value the first three terms would be negligible.

II.—Some Analyses of Nova Scotia Coals and other Minerals.—By E. Gilpin, Jr., LL. D., F. R. S. C., *Inspector of Mines, Halifax, N. S.*

(Communicated March 8th, 1897.)

I purpose this evening to give you a few analyses of Nova Scotia minerals which are of interest.

A set of analyses of Coals from the three seams worked at Springhill by the Cumberland Railway and Coal Company were given me some months ago. They are as follows, and taken from the workings at a depth of from 800 to 1000 feet:

East or No. 1 Slope—Black or Main Seam:

Moisture	2·02
Volatile combustible matter	18·94
Fixed Carbon	75·29
Ash	3·75
	100·00
Sulphur	1·14

West or No. 2 Slope—South Seam. Sample No. 1, from upper division of seam:

Moisture	1·41
Volatile combustible matter	27·93
Fixed Carbon	67·47
Ash	3·19
	100 00
Sulphur	·58

West or No. 2 Slope—South Seam, lower division of seam:

Moisture	1·51
Volatile combustible matter	28·44
Fixed Carbon	65·38
Ash	4 67
	100·00
Sulphur	·61

North or No. 3 Slope—North Seam:

Moisture	2·71
Volatile combustible matter	28·41
Fixed Carbon	64·69
Ash	4·19
	100·00
Sulphur	·79

Analyst—J. T. DONALD, *Montreal.*

These analyses show the coals to be of excellent quality. The amounts of ash and sulpher are small, and that of the fixed carbon is large.

These analyses are interesting when compared with a set of analyses of the same seams made by me in the year 1881, and I believe not hitherto published, and with an analysis of the Black seam made by me in the year 1880, and published in the Transactions of the North of England Institute of Mining Engineers, in a paper on Canadian Coals, giving a full set of analyses of Nova Scotia coals, their ashes, etc.

The analyses made in the year 1881 are as follows:—

East Slope—Black or Main Seam:

Moisture	3·86
Volatile Combustible Matter, Fast Coking	35·65
" " " Slow "	26·46
Fixed Carbon ....Fast "	59·90
" " ....Slow "	65·23
Ash	4·45
Specific Gravity	1·29
Theoretical Evaporative Power	8.858 lbs.

West Slope—South Seam:—

Moisture	1·399
Volatile Combustible Matter, Fast Coking	34·808
" " " Slow "	31·225
Fixed Carbon ....Fast "	58·003
" " ....Slow "	61·586
Ash	5·790
Sulphur	·808
Theoretical Evaporative Power	8·46 lbs.

North Slope—North Seam:

Moisture		1·625
Volatile Combustible Matter,	Fast Coking	33·401
" " "	Slow "	28·672
Fixed Carbon	Fast "	60·701
" "	Slow "	65·431
Ash		4·272
Sulphur		·783
Theoretical Evaporative Power		8.99

The analysis of the Black seam made in the year 1878 has a complete sample column of coal representing the whole seam as then worked. A companion column was presented to the museum of the Geolegical Survey at Ottawa. The section of the seam was as follows:—

	Feet.	Inches.
Top coal, a little coarse	1	7
Coal, good	1	2½
Fire clay parting	—	0½
Coal, good	—	8
Coal, good	1	6
Fire clay parting	—	6
Coal, a little coarse	—	9
Coal, good	—	11
Fire clay parting	—	1
Coal, good	2	2
Coal, good, one inch soft	—	3
Coal, coarse	—	8½
Total	10	4½

I need not repeat here the minute description given then of the various layers. It may be stated that the coal of the sample was bright, with occasional calc-spar and pyrites films, with somewhat irregular fracture. In the vicinity of the point in the mine where the sample was taken a large amount of coal was beautifully iridescent, recalling that splendid mineral Chrysocolla. Samples of this when analysed with the means at my disposal did not give a reason for the coloring. It may have been due to some process of oxidation of iron pyrites.

Each band of coal was analysed with the following results:

Band, No.		1.	2.	3.	4.	5.	6.	7.	8.	9.
Moisture		.98	.76	1 21	.30	.63	.90	1.34	.56	.41
Volatile Comb. Matter	Slow Coking	30.84	32.22	33 81	29.19	28.90	34.56	33.64	30.27	28.54
	Fast Coking	34.75	36 12	37.25	32 65	33.84	35.17	35.94	33.88	30.47
Fixed Carbon	Slow Coking	60.73	60.91	63.13	67.95	65.16	60.59	59.86	60.89	63 63
	Fast Coking	57.82	57.01	59.60	64.48	60.22	59.98	57.56	57.28	61.70
Ash		7 45	6.11	1.85	2.56	5.31	3.95	5.16	8.28	7.42
Sulphur		.85	.56	.79	1.21	1.85	.89	1.40	2.65	2.25
Specific Gravity		1.31	1.30	1.28	1.27	1.29	1.28	1.29	1.33	1.32
Theoretical Evap. Power	Slow Coking	8.33	8.40	8.65	9.28	8.92	8.32	8.20	8.35	8.99
	Fast Coking	7.95	7.65	8.20	8.83	8.30	8.20	7.88	7.75	8.54

Coke bright and tolerably compact.
Ash of average sample grey, with tinge of pink.

The average of the analyses calculating the respective thickness of the bands is about:—

Moisture			·78
Volatile Combustible Matter,	Slow	Coking.	31·32
" " "	Fast	"	33·45
Fixed Carbon	Slow	"	62·54
" "	Fast	"	59.53
Ash			5·34
Sulphur			1·38

The ultimate analyses of the coal gave:—

Carbon	78·51
Hydrogen	5·19
Oxygen, Nitrogen	9·98
Sulphur	1·12
Ash	5·20
	100·00

As compared with the coal from other Provincial districts the Cumberland coals stand as follows:—

	Cape Breton.	Pictou.	Cumberland.
Moisture	·75	1·19	1·86
Volatile Combustible Matter	37·26	29.10	26·76
Fixed Carbon	58·74	60·63	66·65
Ash	3·25	9.34	4·70

From a comparison of the later with the older analyses it will be seen that those of coal from the deeper portions of the seams show lessened amounts of volatile combustible matter, increased percentages of fixed carbon, and diminished amounts of sulphur and ash. Speaking in general terms the coal would appear to have developed more into a steam fuel, the evaporative power being in a general way proportionate to the percentage of fixed carbon.

This would give the coals as at present mined a high calorific power. From analyses by Mason and Matheson in a paper read before the Nova Scotia Mining Society, it would appear that the calorific powers of coals from the Sydney coal fields vary from 7238 to 7623; of Pictou coal (sample from Intercolonial mine) 6963; and of Springhill coal 7898.

As compared with United States coal they should stand nearly in the rank of the best free burning coals of Pennsylvania, Virginia, and Maryland. Those coals hold from 12 to 21 per cent of volatile matter, and from 69 to 76 per cent of fixed carbon. The average contents of the United States coals are from 29 to 35 per cent of volatile matter and from 53 to 67 per cent of fixed carbon. These coals therefore from Springhill should rank for steam purposes next to the class which may be described as the best selected for use on the large ocean passenger vessels.

I have not at hand any proximate analyses of English coals to compare with these under consideration. However, taking the results obtained in the English Admiralty trials of steam coals, and comparing the percentage of fixed carbon found in the trials with the fixed carbon given in these analyses, it will be found that the English and Scotch coals run from 49 to 88 per cent as compared with 68.2 per cent in the Springhill coals.

This would give the Springhill coal about the same relative position to the best Welsh coals as has already been assigned to it in comparison with the best American coals. The evaporative power of the Springhill coals would, from the analyses, stand higher than that of the English and Scotch coals, and rank next

to that of the best Welsh steam coals. It may be remarked that the best American and Welsh coals would be classified as free burning, semi-anthracite, while the Springhill coals are bituminous and coking.

I also give here an analysis of the Patrick seam as worked on the Patrick Lease, now the property of the Canada Coals and Railway Company, on the west bank of the Macan River. The sample is from the lower part of the seam :—

Moisture	1·00
Volatile Combustible Matter	55·61
Fixed Carbon	35·60
Ash	7·49
Sulphur	·50

As reddish and pulverulent.

The following analyses of pit waters may be given here :—

Vale Colliery :—

Water contained in 1000 parts.

Sulphate of Lime	·514
" Magnesia	·100
Silicious matter	·190
Chloride of Sodium	1·452
Carbonate of Sodium	7·509
Iron and Alumnina	Trace.
Organic matter	Trace.

No free acid.

Springhill, from feeder 1300 feet level, water clear, free from smell, slightly acid :—

Sulphuric Acid, free	Trace.
Sulphate of Lime	Large.
" Magnesia	Small.
Chloride of Sodium	Considerable.
Carbonic Acid	Small.
Carbonate of Lime	Small.
Iron Oxides	Small.

Water exerted slightly corrosive action on iron exposed to it for twenty-four hours.

A number of analyses of Nova Scotia mineral and pit waters are given in a paper by the writer, read before the Newcastle Mining Institute some years ago.

In the upper part of George's River in Cape Breton County there is a large deposit of iron pyrites in rocks which are, I think, laid down as Laurentian by the Geological Survey. The deposit has as yet been examined only superficially, but so far appears somewhat low in sulphur. The following analysis of samples from the most promising exposure gives :—

Sulphur	25·00
Copper	1·10
Gold	Trace.
Silver	Trace.
Silica	52·00
Iron, etc	25·00

For a number of years the presence of iron ore at Whycogomah in Cape Breton has been well known. The ores which are magnetites and red hematites are so very favourably situated, being close to the waters of the Bras d'Or Lake, that a good deal of work was done on them a number of years ago. A number of beds were opened and traced. They varied up to nine feet in thickness, and occurred in the Limestone division of the Laurentian, as described by Mr. Fletcher in his numerous reports on the Geology of Cape Breton, issued by the Survey.

The analyses of the ores were contradictory in character, some being high in phosphorus, while others were very pure and ran high in iron. Last fall fresh discoveries were made in this district some distance from the old openings, of beds of magnetite some upwards of 100 feet in width. Indications are not wanting that these ores extend over a large tract of country.

The following analyses will serve to show the quality of the ores :—

Silica	14·41
Alumina	7·33
Manganese Oxide	·61
Lime	3·00
Sulphur	·22
Metallic Iron	54·50
Phosphorus	Trace.
Magnesia	Trace.

Iron.	Phosphorus.	Sulphur.
55·70	None.	·68
59·60	·16	·23
63·20	·004	·31
54·30	·005	·38
53·20	·38	·25
50·74	·31	·024
53·12	·28	·026
52·85	·0058	·138

Silica	21·05
Ferric Oxide	53·54
Ferrous Oxide	21·24
Alumina	2·26
Manganese Oxide	·50
Lime	1·17
Magnesia	·36
Sulphur	·023
Phosphorus	Trace.
Metallic Iron	54.00

Metallic Iron	54·36
Phosphorus	·38

Silica	13·00
Metallic Iron	55·70
Sulphur	·68
Phosphorus	Trace.

These analyses show that there are ores in this vicinity valuable enough for shipment as regards quality, and the present owners consider that new explorations now being carried on will show that the ore is present in quantities sufficient to warrant working on a large scale.

In this connection reference may be made to this division of the Cape Breton Laurentian in which these deposits occur. It may be distinguished as the Limestone division, as it is distinguished mineralogically from the other, or felsite division, by the presence of numerous beds of limestone, in addition to the felsites, gneisses, granites, etc., common to both. These limestones furnish marble, as at West Bay and other localities, lime

of excellent quality, and dolomites, suitable, as at New Campbellton, for furnace linings. Iron ores occur in them at numerous points both hematite and magnetite. Graphite is also found In all probability, phosphates, similar to those found in Quebec will be proved on search being made. Where these measures are cut by dykes, copper and lead ores carrying gold and silver occur, and may in some cases prove valuable. As yet so far as my information goes free gold has not been found in quartz in the limestone division. The gold of Middle River and Cheticamp appears to be associated with soft talcose and felsitic schists of the other division. This gold occurs at Middle River free in quartz, and in the river gravel, derived presumably both from the quartz and augmented by gold flakes from the schists. At the Cheticamp River, so far as can be judged from the work done, it would appear to have a similar source, and to be connected only with the felsite series. In the latter case part of the gold may be derived from mineralized zones adjoining the dykes cutting the various rocks. However, the explorations of the coming season will probably give us more exact information. It is interesting to note in connection with the occurrence of gold at Cheticamp that native silver occurs in the Mackenzie River a short distance north, and it is possible that explorations in that section may result in the discovery of important amounts of this metal and associated gold.

III.—NOTES ON NOVA SCOTIAN ZOOLOGY: No. 4.—BY HARRY PIERS, *Halifax, N. S.*

(Read 12th April, 1897.)

In the following paper is recorded anything of interest regarding the zoology of the province that has come to my notice during the past year or two. Former contributions on the same subject will be found in recent volumes of the Transactions of this Society.

MAMMALS.

GRAY SQUIRREL (*Sciurus carolinensis*). The capture of a specimen of this large species is recorded in a former paper of mine (vide *Trans. N. S. Inst. Nat. Sc.*, vol. vii., p. 467). Another was killed, May 20th, 1894, near the old sugar refinery, on the western side of the North-West Arm, Halifax.

RED FOX (*Vulpes vulpes* var. *fulvus**). In the winter of 1893-4, an albinistic Fox was killed at Musquodoboit, Halifax County, and was brought to Mr. A. G. Kaizer, furrier of this city, who subsequently sold it to Captain Campbell. The general colour of the pelt was cream white with a rusty tinge. Each hair of the tail was tipped with black, giving the whole brush the appearance of having been slightly singed. More of this black was towards the end and underside of the tail, but the extreme tip was whitish. Posterior parts of ears, black; but inside, white. Snout dusky. On the chest, a little behind the four legs, was a lead-coloured blotch which merged into the surrounding colour of the under parts. A white line margined with black extended on the front of the hind legs, from hock upward; front of hind legs, from hock to claws, black. Length of pelt from snout to tip of brush, four feet.

* Mr. Outram Bangs in a paper published in the *Proceedings of the Biological Society of Washington* (March 16, 1897), describes a new form of Fox from Nova Scotia under the name *Vulpes pennsylvanica vafra*, it being distinguished from the typical *V. pennsylvanica* (= *fulvus*) by its larger size and deeper colour. Mr. Bangs also considers the American Red Fox entirely distinct from the European species (*V. vulpes*).

Mr. Kaizer informs me that some years ago he obtained a similar skin. This and the specimen just described, are the only albino Red Foxes he has ever seen, although he handles very many pelts.

Regarding the Silver Fox (var. *argentatus*), a well-known variety of the Red Fox, Mr. Kaizer tells me that while it is found on the Island of Cape Breton and in the eastern and western parts of Halifax County, and sometimes also in Guysborough, yet he has never for thirty years heard of its capture west of the County of Halifax. He is therefore inclined to think it is somewhat local in distribution.

BIRDS.

ROSEATE TERN (*Sterna dougalli*). On June 2nd, 1894, Mr. T. J. Egan obtained a specimen which had been shot at Prospect, Halifax County, N. S., a day or two before.

MALLARD (*Anas boschas*). A male was shot at Cole Harbour, Halifax County, on October 17th, 1895, and was brought to Mr. W. A. Purcell. Another, killed at the same place, was in the Halifax market on November 2nd, of that year. It had evidently been taken two or three days before. The Mallard is a rare Nova Scotian bird.

WOOD DUCK (*Aix sponsa*). Mr. Purcell informs me that a male Wood Duck was shot several miles westward of Halifax (at Joshua Umlah's) about September 18th, 1895, and another was taken about the same date near Three Fathom Harbour.

KING EIDER (*Somateria spectabilis*). A fine specimen, a male, of this rare winter bird was killed on February 22nd, 1895, at Devil's Island, at the mouth of Halifax Harbour. Another male was taken at Three Fathom Harbour, Halifax Co., about March 20th, of the same year. Both birds were brought to Mr. Purcell. One or two other specimens were in the Halifax market about the last-mentioned date.

LEAST BITTERN (*Botaurus exilis*). In March, 1896, a bird of this species was brought to me for identification. I examined it

"in the flesh" and found it to be an adult male in full breeding plumage; total length, 14 ins.; wing 4.70; bill 1.88. It had been shot by Thomas Beck on the 16th of the above mentioned month, at Upper Prospect, Halifax County.

This small, handsome species has never before been met with in Nova Scotia, and its occurrence here is remarkable. Its regular range in the east only extends as far north as Massachusetts, but stragglers have been taken in Maine and New Brunswick. In the latter province some five individuals were shot between 1877 and 1881, on the Bay of Fundy shore between Black River and Mispeck (Chamberlain, "Catalogue of Birds of New Brunswick"). In Ontario, Mr. McIlwraith reports it as generally distributed throughout the south part of the province, and as a regular summer resident at Hamilton Bay (*Birds of Ontario*, 2nd ed., p. 108.) Its presence in Nova Scotia is the more remarkable when we consider the very early period of the year in which it was taken; a time when only the more hardy birds arrive here.

Little Blue Heron (*Ardea cærulea*). On March 18th, 1896, a male of this species, in adult plumage, was killed at Lawrencetown, Halifax County. The bird was thin and had evidently had but little food for some time. It was brought to Mr. Egan. On April 10th, 1897, another specimen, an adult, was taken at Sheet Harbour. It was mounted by Mr. Egan and now belongs to Mr. Hart of Halifax.

With these two exceptions, the species has only once been collected in the province. The late Mr. J. Matthew Jones reported that a specimen was taken at Cole Harbour, near Halifax, during the summer of 1884, (*vide* Chamberlain's *Catalogue of Canadian Birds*). The specimen referred to by Mr. Jones was formerly in the collection of Mr. Egan, but is now owned by the Fisheries Department at Ottawa. It was in whitish immature plumage.

Purple Gallinule (*Ionornis martinica*). This handsome but somewhat bizarre species is an accidental visitor in Nova Scotia. Two specimens have been taken in the province in pre-

vious years, one having been killed near Halifax on January 30th, 1870 (Jones, *American Naturalist*, iv., 253), and another captured in April, 1889 (vide *Trans. Inst. Nat. Sc.*, vii., 468). It not unfrequently comes as far north as the New England States, but in Canada has only been reported from our own province, New Brunswick and Ontario, in all of which localities its occurrence is merely casual.

In 1896, I saw a adult female which had been captured alive on Devil's Island, Halifax Harbour, about January 16th of that year, the bird had evidently struck the lighthouse on the island and fell to the ground disabled. It was kept alive for about twenty-five days when it died and was mounted by Mr. Walter Brett. S. Fraser of Halifax, who now possesses the bird, also has another of the same species, which he tells me was found dead at Chezzetcook, Halifax County, in the same week as that in which the above-mentioned specimen was taken.

WILSON'S SNIPE (*Gallinago delicata*). About October 11th, 1894, there was shot at Canning, King's County, a Snipe whose colours were so very light and tinged with gray, as to constitute partial albinism. It was mounted by Mr. Purcell for Mr. Dickie, of Canning. On December 3rd, 1894, I noted a Snipe at Halifax—the latest date on which I have seen the species. There was about five inches of snow on the ground at the time. The last Snipe of the regular body was noted on November 21st of that year. I have been told that individual birds occasionally remain very late in the season.

LAPWING (*Vanellus vanellus*). This is another purely accidental visitor in our province. The species is a native of the northern portions of the eastern hemisphere, although it occasionnally has braved the perils of the Atlantic and been found in Greenland.

On March 17th, 1897, an individual of this species was found, lying dead, on the sand of the shore at Ketch Harbour, near Halifax, N. S. It was very thin and death had evidently

been largely owing to starvation. The bird was brought to Mr. Egan's store, where I examined it before it was skinned.

It is doubtful if there is another well authenticated record of the occurrence of this bird in temperate America, for Mr. Ridgway in his Manual places a query after "Long Island" in the list of localities where it has been met.

MOURNING DOVE (*Zenaidura macroura*). Several Mourning Doves were taken in Halifax County during October, 1896. Mr. Searle, taxidermist, had three specimens: one killed about October 2nd; another shot at Terence Bay, about October 6th; and a third killed about the 9th. I also saw a fourth specimen in the market on October 10th, which had been killed at Porter's Lake, probably the day before. Mr. Francklyn of Halifax purchased a specimen in the market on September 28th, 1895. It had likely been killed on the previous day. Still another specimen was shot at Canning, N. S., by C. R. Dickie, on November 4th, 1895.

BLACK VULTURE (*Catharista atrata*). On January 12th, 1896, a Black Vulture was killed at Pugwash, Cumberland Co., N. S., and two days later was brought to Mr. Egan. I examined it after it had been mounted and identified it as the above species. It measured as follows: wing 17.75 ins., tail about 7.50, culmen .93, tarsus 3.13, middle toe without claw 3.

The occurrence of this bird in our limits is remarkable, and is doubly so when we consider the period of the year in which it was taken. It is regularly found as far north as North Carolina, and has been met as a casual visitor in the New England States, and Chamberlain (Nuttall's *Ornithology*, 1891,) records that it has even been killed on Grand Manan in the Bay of Fundy. With this exception, it has not hitherto been met with in Canada.

BROAD-WINGED HAWK (*Buteo latissimus*). In September, 1894, Mr. Purcell showed me a hawk which I identified as a young bird of the above species. It had been shot at Windsor,

N. S., on the 9th of the month. The species is very rare about Halifax, althongh in some portions of the Maritime Provinces it has been reported rather common. The bird is evidently local in distribution.

DUCK HAWK (*Falco peregrinus anatum*). About 1893, Mr. Austen mounted an adult male which had been killed on Devil's Island, at the mouth of Halifax Harbour. The bird is very rare in Nova Scotia. Two individuals were taken on McNab's Island in September, 1892, as recorded in "Notes on Nova Scotian Zoology, No. 3."

AMERICAN HAWK OWL (*Surnia ulula caparoch*). This owl has now become rare in the province. In the winter of 1895, Mr. Purcell had four specimens—a most unusual number: a pair purchased in the Halifax market on November 16th, probably from near Musbuodoboit; one brought in, November 23rd, by John Paul, Indian, who had killed it near Salmon River, Halifax County; and another brought to town on December 2nd, from West Chester where it had been taken. All were quite fresh and had evidently been shot only a day or two before.

PILEATED WOODPECKER (*Ceophlœus pileatus*). A female was shot at Liverpool, N. S, on October 17th, 1895; another female was taken on the Windsor Road, Halifax County, about November 3rd, 1896; a male was brought to Mr. Purcell on January 6th, 1897; and a fourth specimen was killed at Oxford, Cumberland Co., about February 10th, 1897.

AMERICAN CROW (*Corvus americanus*). A curious freak of nature is found in a partially albinistic Crow which was shot at Shad Bay, Halifax Co., on October 6th, 1896. It agreed perfectly with descriptions of normal individuals except in the colouring, which may be more particularly described as follows: general colour brown (umber brown or light hair-brown), darker on throat, cheeks and belly; scapulars and feathers of back margined obscurely with whitish; primaries mostly whitish; tertials white; tail feathers light reddish brown (cinnamon

rufous) margined with whitish on outer edge; legs and bill dark-brown; eyes brown. Measurements: wing, 12.90 in.; tail, 7.50; exposed culmen, 1.93; depth of bill at base, .92; tarsus, 2.37.

BOBOLINK (*Dolichonyx oryzivorus*). As is well known, this bird is now exceedingly rare at Halifax, although formerly it was rather common. On the marshes in the western parts of the province it is still very abundant. On May 20th, 1895, while walking past a field in the western part of Halifax, my ears were saluted by the rollicking, gurgling notes of a Bobolink, and I saw a fine male in full plumage sitting on the top rail of a fence. His notes brought to my mind the flat, diked lands of Grand Pré and Windsor. I went over a wall after him and soon he flushed out of the wet grass and in full song flew to the top-rail of a neighbouring fence, where he alternately pruned his feathers and sang his glorious song. This ditty begins with a few metallic notes, somewhat bell-like in tone, from which the singer proceeds helter skelter into an inimitable rush of liquid, light-hearted music.

On May 28th, 1897, I heard another Bobolink singing in a swampy bit of grass-land on the side of Chebucto Road, near the North West Arm, Halifax.

In May, 1896, my friend Mr. Walter Brett, of Sackvllle, N. S., showed me a specimen which he had collected at that place. He also informs me that during the spring he saw two males: one at Sackville and the other on the Bedford rifle-range. Still another, a young male, was taken by him on September 13th, 1897. It therefore is evident that the bird is found occasionally on the meadows bordering the Sackville River.

MEADOW LARK (*Sturnella magna*). On October 24th, 1895, a Meadow Lark was obtained by Mr. Dickie, of Canning, King's Co. The bird is very rare in this province.

BRONZED GRACKLE (*Quiscalus quiscala æneus*). On November 9th, 1894, one of these Grackles was shot on the Preston

Road, about two miles from Dartmouth, by Mr. Watson L. Bishop. There was about four inches of snow on the ground. It is the first of the species he has obtained, although he had collected for many years near Kentville, in the western part of the province. About Pictou, I understand, the species is more common, but near this city it is rare.

NORTHERN SHRIKE (*Lanius borealis*). This is a rare winter visitor in Nova Scotia. Mr. Francklyn shot a specimen at the North West Arm, Halifax, on February 22nd, 1895. The bird at the time was engaged in killing Snowflakes (*P. nivalis*). Another was obtained at Canning, King's Co., on March 1st of the same year, by Mr. Dickie.

BAY-BREASTED WARBLER (*Dendroica castanea*). In a previous article (" Notes on N. S. Zoology, No. 2") I noted a nest and two eggs of this warbler which had been collected by Mr. Austen. The same gentleman informed me that during the summer of 1895 he found two more nests at Dartmouth, near Halifax. One of these, containing four eggs, was taken during the latter part of June, and the other was collected about July. Nests and eggs of this species are rare.

BLACKBURNIAN WARBLER (*Dendroica blackburniæ*). During the summer of 1896 Mr. Walter Brett, of Sackville, Halifax County, took one specimen at that place. The late Mr. Downs considered this species very rare. Mr. Chamberlain thinks its secluded habits may have given rise to its reported rarety in Canada.

WINTER WREN (*Troglodytes hiemalis*). An account of the very rare nest and eggs of this wren has already appeared in the publications of the Institute (*Transactions*, vol. viii., p. 203). On June 11th, 1894, my brother and myself found another nest of the species at the Rocking-stone (Kidston's) Lake, Spryfield, Halifax County. It was only a few feet away from the spot in which was situated the one described in the paper just referred to. As far as could be observed, the second nest was

precisely like the first in form, construction and materials. Both were built in moss, which was constantly saturated with water trickling from the bank above and slowly flowing over the top of the stone upon which the moss grew. The present nest contained a number of young, which we could just reach with the tip of the finger. There is not the slightest doubt about identitication, for one of the parent birds was seen entering and leaving the opening a number of times. It is quite likely that this nest was constructed by the same birds which built the one found in May, 1891.

RUBY-CROWNED KINGLET (*Regulus calendula*). Mr. Austen, to whose exertions we owe much of our knowledge of the eggs and nest of this little bird, found two more nests at Dartmouth during the month of June, 1895. One of these contained eleven eggs, the other seven. Both were suspended beneath the limbs of black spruces. He tells me that nests of both the Ruby-crowned and Golden-crowned Kinglets may be found either on the limb or suspended beneath, so that the situation of the nest does not decide to which species it belongs.

REPTILES.

RING SNAKE (*Diadophis punctatus*). On July 24th, 1896, Mr. Augustus Allison saw one of these very rare snakes in Point Pleasant Park, Halifax, but he was unable to capture it. As well as he could judge, it measured about 10 or 11 inches in length. On the 17th of the succeeding month, on passing near the same place, he picked up a snake that had been crushed by a wheel. It proved to be *D. punctatus.* He kindly lent me the specimen, which I examined after it had been in alcohol for about a day. It furnished the following description: back, bluish black with slightly violet reflections in some lights. Beneath, orange buff, deepest about anus, palest on throat. Occipital stripe two scales wide, yellowish orange (nearly as deep in colour as abdomen near anus). Blackish spots on centre of each abdominal scutellum from near throat to near anus. These spots are small and round on anterior part of body,

transversely longer on posterior part. Lateral ends of each abdominal scutellum with a blackish, somewhat triangular mark. Length, 14.25 inches; tail, 3.70; greatest diameter of body, .30. Fifteen rows of dorsal scales.

TRUNK-BACK or LEATHER TURTLE (*Dermochelys coriacea*). The occurrence of this animal in Nova Scotian waters has only once been previously recorded. In my "Notes on N. S. Zoology [No. 1]", was described a specimen which had been taken near Prospect, N. S., about August 30th, 1889.

In 1894 I had an opportunity of examining a second one, which had been taken on September 9th of that year by a man named Dauphiney, who found it entangled in his mackerel net about three miles off Hubbard's Cove, St. Margaret's Bay, to the westward of Halifax. It was brought to land and kept alive until September 13th, when it died, and was taken to Halifax for preservation. Subsequently it was placed on exhibition. The following measurements were taken after the reptile had been stuffed, and consequently a few of them are only approximately accurate: total length, 86 inches (7 ft. 2 ins.); length of head, 10 ins.; greatest breadth of head, 8¾ ins.; breadth between orbits, 4 ins.; length of fore-paddles, 32 ins. (*plus* about 2 ins., which had been worn off); greatest breadth of fore-paddles, 11 ins.; length of hind-paddles, 14 ins.; greatest breadth of hind-paddles, 10½ ins.; length of tail (may have been extended in mounting), 12 ins.; length of dorsal shell or carapace, 58 ins.; breadth of dorsal shell, 34 ins.; depth of notch in posterior margin of hind-paddles, about ½ in. The furrows or grooves in the shell were not so deep as those in the specimen of 1889. This is probably owing to a difference in age.

On August 16th, 1895, another of these turtles was captured off the same place (Hubbard's Cove) and was brought to a fish-dealer in this city. I examined it on August 20th while it was alive in a tank of water. As the animal was moving about, it was difficult to obtain exact measurements, but the following are very nearly accurate. Total length, 75 ins. (6 ft. 3

ins.); length of head, 10 ins.; breadth of head between orbits, 4 ins.; length of fore-paddle, 34 ins.; length of dorsal shell or carapace, 52 ins. This last measurement, however, does not include about six inches of the posterior point of the carapace, which had apparently been broken off. Each hind-paddle had a well-defined notch, about one inch deep, on the posterior margin. Such a notch was observed in the specimens taken in 1889 and 1894. In the present individual there was a hole, about an inch long, through the left fore-paddle. This was probably an old wound, for there was no indication that the turtle had ever been secured thereby.

The Trunk-back is a wandering species, whose presence on our coast is entirely accidental.

Fish.

Sunfish (*Mola mola*). This is a rare visitor to our coasts. Only two specimens have been previouly recorded—one by the late Dr. Gilpin and the other by the present writer. On July 18th, 1894, one was captured by a man named Reino, about ten miles off Devil's Island, at the mouth of Halifax Harbour. It was brought to Halifax, where I examined it, and found that it differed only in size from the one taken in August, 1889. The length of the present specimen from tip of snout to end of most remote digitation of tail, was about 53.50 inches. From tip of dorsal fin to tip of anal fin it measured 67 inches. There were about ten scallops or digitations on the tail. Several parasites (*Pennella filosa ?*) had penetrated the sides of the fish in like manner to those noted in the specimen of 1889.

On August 14th, 1895, while on the shores of Bedford Basin with my brother, we noticed a black object appearing and disappearing on the glassy surface of the water about half a mile from shore. From the peculiar motion and form of the object it was recognized as the dorsal fin of a Sunfish. The animal was watched for some time as it rolled its fin out of the water and then back again, meanwhile progressing very slowly. It was

evidently basking on the calm, warm surface. At times we thought another fin could be seen above the surface at a little distance from the first one; and if this was so, a second fish must have been present. Finally we obtained a boat and rowed out to the bobbing black fin. The boat was put alongside the animal, which made no attempt to escape. It was lying on its side at the surface, a yard or two from us, and in full view. We estimated its length to be about 5½ feet, and it did not differ in shape from former specimens. It showed no alarm until struck with a pole, when it slowly sank, turned over, and propelled itself away beneath the surface by lateral movements of the dorsal and anal fins. It soon came up and once more waved its dorsal in the air. On being touched, it again went out of sight, but soon re-appeared and then sank once more. Finally the fin rose out of the water not far away and we pulled alongside. The animal, however, was now more alarmed, and on being merely lightly touched with an oar, turned over and, more rapidly than before, made off in an oblique direction downward. It was beneath for some time, and then appeared close to the shore, but was very shy and disappeared as soon as approached. A little later a wake was seen on the surface of the smooth water, progressing with a good deal of rapidity. It was without doubt caused by the fish swimming a little beneath the surface. It made toward the shore and then sheared off and went close along the beach, but in deep water, and then finally disappeared.

BATRACHIANS.

RED EFT (*Diemyctylus viridescens* = *miniatus*). The viridescent form of this species has been reported in the province by Dr. MacKay and myself, but the red, immature land form (*miniatus*) has not previously been collected. About October 10th, 1896, however a red terrestial specimen was taken at Lakeview, near Bedford, by Miss M. H. King, and was brought to me for identification.

Up to a few years ago these young specimens had been a great enigma to scientists. The red form is so different in

coloration from the older, viridescent one, that it was originally considered an entirely distinct species under the name *miniatus*, and even at one time was placed in a different subgenus. The late Prof. Cope in 1859 expressed the opinion that *miniatus* was only a state of *viridescens*, but it was not till a number of years later that the whole process of transformation from immature to mature pigmentation was observed in captive animals and fully described. The red specimens are found upon land, whereas the viridescent, full-grown form is aquatic in habits.

IV.—Phenological Observations, Canada, 1896. Compiled by A. H. MacKay, LL. D., *Halifax.*

(Read 10th May, 1897.)

I present here, in tables A and B, the observations made at twenty-two stations throughout Canada. The Province of Nova Scotia has by far the largest representation as usual; but that is not remarkable, as the observations were commenced in 1892 at Nova Scotia stations alone. In 1893 four New Brunswick stations were added. In 1894 the stations were extended to Winnipeg, and in 1895 to Vancouver.

In addition to the Dominion tables referred to, I give as a sample of problems which may be solved by an annual series of such tables, one showing the average date for five years of the first appearance of twenty objects in the Province of Nova Scotia. When these tables become fuller, as they promise to do in the future, averages for each station during a term of years would give interesting normals for each station for the comparison of the variations of climate from year to year. The comparison of the normals of each station throughout a province would be even more interesting. The publication of these tables will put all such data at the disposal of those wishing to utilize them for general or local purposes at present or in the future.

I expect this summer to have such reports from very many stations in Nova Scotia, as a great many of the public schools are making observations on a list of 100 objects in their respective stations in every quarter of the Province.

Stations and Names of the Observers, 1896.

Nova Scotia.

Yarmouth, Yarmouth Co.—Miss Antoinette Forbes, B. A.
Berwick, Kings Co.—Miss Ida Parker.
Maitland, Hants Co.—Miss Bertha B. Hebb, B. A.

Halifax, Halifax Co.—Mr. Harry Piers.
" " Mr. G. M. Johnstone MacKay.
Amherst, Cumberland Co.—Principal E. J. Lay.
New Canaan, Cumberland Co.—Miss Sarah C. Ross.
River Philip, Cumberland Co.—Miss Jean McLeod.
Wallace, Cumberland Co.—Miss Mary E. Charman.
Pictou, Pictou Co.—Mr. C. L. Moore, B. A.
" " Mr. C. B. Robinson, B. A.
New Glasgow, Pictou Co.—Miss Maria Cavanagh.
Antigonish, Antigonish Co.—Prof. D. M. MacAdam.
Port Hawkesbury, Inverness Co.—Mrs. Louise Paint Forsyth.

Prince Edward Island.

Charlottetown, Queens Co.—Principal John MacSwain.

New Brunswick.

Saint John, St. John Co.—Geo. U. Hay, M.A., Ph. B., F. R. S. C.
Richibucto, Kent Co.—Miss Isabella J. Caie.

Ontario.

Niagara Falls, Welland Co.—Mr. Roderick Cameron.
Beatrice, Muskoka Co.—Miss Alice Hollingworth.

Manitoba.

Reston, Dennis Co.—Mr. H. B. MacGregor.

Assiniboia.

Pleasant Forks—Mr. Thomas R. Donnelly.

British Columbia.

Vancouver City, High School—Mr. J. K. Henry, B. A.

TABLE A.

PHENOLOGICAL OBSERVATIONS, CANADA, 1896.

Number.	Day of the year, 1896, corresponding to the last day of each month. January......... 31 July........... 213 February .... 60 August........ 244 March........... 91 September..... 274 April........... 121 October........ 305 May............ 152 November..... 335 June............ 182 December..... 366	Yarmouth, N. S.	Berwick, N. S.	aitland, N. S.	Halifax (P), N. S.	Halifax (M), N. S.	Average Southern Nova Scotia	Amherst, N. S.	New Canaan, N. S.	River Philip, N. S.
1	Alder, shedding pollen...............	106	102	...	110	..	106·0	111	...	111
2	Aspen, shedding pollen..............	...	123	...	...	...	123·0	114	...	111
3	" leafing out	...	139	..	144	...	141·5	...	..	...
4	Spring Anemone, flowering...........	...	.	...	...	...	.....	..	..	...
5	Red Maple, flowering	106	125	..	117	...	116·0	126	...	. .
6	Hepatica, flowering.................	..	...	. .	..	...	.....	...	...	..
7	Adder's Tongue Lily, flowering	...	...	...	...	...	.....	...	126	...
8	Mayflower, flowering................	82	103	100	102	103	98·0	96	...	109
9	Dandelion, flowering................	116	135	129	131	130	128.2	130	131	...
10	Salmon-Berry, flowering.............	..	...	...	...	...	.....	..	...	...
11	" " fruiting..............	...	...	.	...	...	.....	...	...	...
12	Negundo, flowering..................	...	...	...	...	...	.....	...	..	...
13	Strawberry, flowering...............	122	125	123	137	130	127·4	128	128	125
14	" fruiting..................	151	157	...	...	...	154·0	170	175	161
15	Prunus Americana, flowering.........	...	..	...	...	...	.....	...	..	...
16	Cherry (cultivated), flowering.......	..	137	...	...	...	137·0	141	152	...
17	" " fruit............	...	...	...	.	...	.....	...	...	...
18	Wild Red Cherry, flowering..........	147	141	..	144	146	144·5	. .	139	138
19	Indian Pear (Amelanchier), flowering..	140	138	...	144	137	139·7	141	143	...
20	" " " fruiting...	...	..	...	...	...	.....	...	...	...
21	Blackberry (Rubus ?), flowering.......	...	...	...	..	. .	.....	143	174	...
22	Apple (cultivated), flowering.........	143	153	...	152	...	149·3	149	152	145
23	Western Dog-wood, flowering.........	...	...	...	...	...	.....	...	..	...
24	Oaks, flowering.....................	...	...	...	162	...	162·0	...	...	...
25	Hawthorns (Crataegus) flowering	165	...	...	166	...	165·5	...	...	161
26	Lilac (cultivated), flowering	154	157	. .	162	157	157·5	162	...	159
27	Raspberry (wild), fruit ripe	...	...	...	...	...	.....	...	...	...

TABLE A.—*Continued.*

PHENOLOGICAL OBSERVATIONS, CANADA, 1896

Number.	Wallace, N. S.	Pictou (M), N. S.	Pictou (R), N. S.	New Glasgow, N S.	Antigonish, N. S.	Port Hawkesbury, N S.	Average Southern Nova Scotia.	Charlottetown, P. E. I.	Saint John, N. B.	Richibucto, N. B.	Niagara Falls, O.	Muskoka, O.	Reston, Man.	Pheasant Forks, Assa.	Vancouver, B. C.
1	103	106	107	....	117	....	109·1	141	114	116	107	106	....	....	70
2	....	...	120	119	....	140	120·8	136	121	....	109	116	....	136	....
3	. ..	140	140	146	153	153	146·4	....	...	140	....	30	....	...	....
4	....	....	....	....	....	....	.. ...	....	130	...	117	....	112	116	.. .
5	139.	135	130	131	133	138	133·1	137	122	131	111	124	....	....	....
6	....	....	....	....	....	....	......	....	122	....	107	124	..	....	....
7	....	130	129	129	.. .	..	128·5	....	128	....	107	111	....	....	....
8	110	106	105	108	108	117	107·4	113	128	117	...	115	...	....	....
9	128	129	129	124	125	135	128·9	139	128	138	119	124	....	149	88
10	....	....	....	....	.. ..	...	....	....	....	....	....	....	....	.. .	82
11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	162
12	....	....	....	....	....	....	....	....	....	....	116	....	133	....	....
13	130	130	131	125	132	138	129·6	....	130	127	123	132	144	134	102
14	160	167	....	....	.171	174	168·3	..	183	172	145	161	180	186	150
15	....	....	....	....	....	....	. ...	....	....	....	126	....	141	....	....
16	142	144	....	149	158	157	149·0	....	....	146	118	....	....	....	107
17	188	....	....	206	....	223	205·6	.	....	204	153	....	....	....	....
18	....	149	....	151	153	....	146·0	159	143	145	....	130	....	....	126
19	....	140	140	141	148	152	143·6	....	136	144	118	124	138	150	128
20	....	....	....	....	....	223	......	....	....	208	....	....	.. .	196	.. .
21	....	....	....	....	154	173	.....	....	.. .	. ..	145	....	....	....	126
22	147	....	....	154	157	166	152·9	159	....	152	131	132	....	...	126
23	....	....	....	....	....	....	......	....	....	....	....	....	....	164	135
24	....	....	....	. ..	....	....	......	. ..	...	148	131	....	....	....	....
25	....	155	....	149	....	....	155·0	166	....	160	136	135	138	...	149
26	159	161	....	....	166	174	163·5	....	....	158	132	135	....	....	136
27	....	....	....	....	...	218	......	..	....	....	....	....	194	199	....

TABLE B.

PHENOLOGICAL OBSERVATIONS CANADA, 1896.

Day of the year, 1896, corresponding to the last day of each month.

January	31	July	213
February	60	August	244
March	91	September	274
April	121	October	305
May	152	November	335
June	182	December	366

Number.		Yarmouth, N. S.	Berwick, N. S.	Maitland, N. S.	Halifax (P), N. S.	Halifax (M), N. S.	Average Southern Nova Scotia.	Amherst, N. S.	New Canaan, N. S.	River Philip, N. S.
31	Spring Wheat, first sowing									
32	" " flowering									
33	" " harvesting									
34	Last Spring Frost		146				146·0	144		
35	First Autumn Frost		268		300		284·0	268		
36	Opening of Still Lakes							104		
37	Closing of Still Lakes									
38	Opening of Rivers, Spring									
39	Closing of Rivers in Fall									
40	Thunderstorms								100	
						130		139	140	
						144			143	
			173			172		172	172	
						174			173	
								212		
			222					222		
			232							
41	Droughts affecting Vegetation									
42	Song Sparrow, first appearance		95	97	*74	103		98		
44	American Robin, Eastern		83	95	*104	103		92		
45	Merŭla propinqua, Western									
48	Junco, Eastern species		104		104			116		
49	" Western species									
50	Red-Winged Blackbird									
51	Spotted Sandpiper		137		105					
52	White-bellied Swallow		126	109	117			101	126	
53	Meadow Lark									
54	Kingfisher							120		
55	Hummingbird, first appearance		138		136			143	140	
56	" Western species									
57	Night Hawk, Eastern species		147		139					
58	" " Western species									
59	Wild Ducks, first birds							101		
60	" " " Flocks									
61	" " last Flock				298					
62	" " " Birds									
63	Wild Geese, first Birds		92		93					
64	" " " Flock							78		
65	" " last Flock									
66	" " " Birds				346					
67	Frogs piping, first date		107	108	106			105	110	

* Winters in.

TABLE B.—*Continued.*

PHENOLOGICAL OBSERVATIONS, CANADA, 1896.

Number.	Wallace, N. S.	Pictou (M), N. S.	Pictou (R), N. S.	New Glasgow, N. S.	Antigonish, N. S.	Port Hawkesbury, N. S.	Average Southern Nova Scotia.	Charlottetown, P.E.I.	Saint John, N. B.	Richibucto, N. B.	Niagara Falls, O.	Muskoka, O.	Reston, Man.	Pheasant Forks, Assa.	Vancouver, B. C.
31					125			127		127			114	126	
32													191		
33				237				227		221			221		
34	166				165	176	162·7	144		159	113		137		
35	281				249	239	259·2	266		275	266	248		215	
36						118									
37					329	353	341·0								
38					72			101		109	89		106	95	
39	357							356		336			309	295	
40	110					111		110		109	89	107	126	98	
	133					139		111			109		129		
	169							131			113	146	132	145	
	173					172		174		156	128	157	137	158	
	174							185		170	136	159	162	169	
	180							192		174	138		166		
	194							194		194	148		168		
	197					197		197		197	158		169		
	203										160		174		
	213					215		208					178		
	217					232		217		217			186	215	
	222					242		225		222			190		
	225					250				249			198		
	251					260							214		
	263					263							217		
						279									
												303			
												323			
41													178 to 198		
42						101		101			88				
44				99		97		102		106	88	95			
45											89		119	105	
48								101							
49													291		
50											88		114	105	
51											104				
52	116					130		137		116	105		135		
53											94		97	108	
54						124				116	103				
55	139			138		141				138	140	121			
56											140				
57						177		179				141		149	
58													134		
59						*					88		104	87	
60								91			88		111	106	
61						264									
62															
63	67	75									87	118	87	87	
64	68					80		98		87	87		94	98	
65	252					298		271				317			
66	340														
67	103	103	103		107	111		105		116	105	104	112	115	50

MEAN OF TWENTY PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, FOR THE FIVE YEARS, 1892 TO 1896.

Species common to the Tables of the five years.		Average Date 1892.	Average Date 1893.	Average Date 1894.	Average Date 1895.	Average Date 1896.	Five Year Mean.	Normal date of first flowering, etc.
Mayflower,	first flowering	98	108	104·7	113·55	102·70	104·79	5th April.
Alder,	" "	102	114	116·3	103·8	107·55	108·73	9th "
Aspen,	" "	131	123	122·2	117·5	121·90	123·12	4th May.
Maple,	" "	123	130	126·3	123·85	124·55	125·54	6th "
Strawberry.	" "	129	133	131·6	128·55	128·50	130·13	11th "
Dog-tooth V.,	" "	135	136	132·2	125·	128·50	131·34	12th "
Cherry (Cult),	" "	146	142	146·3	136·6	143·00	142·78	23rd "
Indian Pear,	" "	145	144	146·	138·35	141·65	143·	24th "
Cherry (wild),	" "	150	144	147·	138·15	145·25	144·88	25th "
Apple,	" "	146	146	152·1	166·65	151·10	152·37	2nd June.
Lilac.	" "	154	160	162·3	153·5	160·50	158·06	8th "
Hawthorn,	" "	163	160	160·3	148·75	160·25	158·46	8th "
Wild Goose,	first........	54	88	70·6	78·00	80·00	74·12	6th March
Robin,	"	96	94	73·2	99·30	96·14	91·73	2nd April.
Song Sparrow,	"	99	115	79·	96·65	94·66	96·86	7th "
Frogs piping,	"	105	113	112·8	110·55	106·30	109·53	10th "
Swallow,	"	106	119	119·	125·75	117·76	117·50	18th "
Kingfisher,	"	128	137	128·7	127·50	122·00	128·64	9th May.
Humming Bird,	"	143	159	143·0	137·25	139·30	144·31	25th "
Night Hawk,	"	150	144	158·8	148·00	154·33	151·03	1st June.

V. — Supplementary Note on Venus. — By A. Cameron, *Yarmouth, N. S.*

(Read 10th May, 1897.)

In the Transactions of this Institute for 1892-3, (Second Series, Vol. I., Part 3), there is an article of mine on "Venus in Daylight to Eye and to Opera Glass." On page 345, the late M. Trouvelot of the Observatory at Meudon, is quoted to the effect that in a clear sky Venus may be seen in daylight with the naked eye, when her angular distance from the sun is not less than 10° at inferior conjunction, and not less than 5° at superior conjunction.

On pages 347-8 particulars are given of a naked eye observation made at noon on July 6, 1892, when the angular distance between Venus and the Sun was less than 7°. This was a little over three days before inferior conjunction. Three of these conjunctions have occurred since then—in February, 1894, September, 1895 and April, 1897—but, so far as I know, no closer observation was got at any of them. On the morning of February 14th, 1894, I saw Venus with naked eye, when less than two days before inferior conjunction; but this was not a "daylight" observation as defined in the article cited; and, besides, the elongation was more than 7°. This observation was one of a pair, which, as a pair, had some rather curious features. (See Series II., Vol. I., pp. 391-4.)

The chief purpose of this note is to make a few additions to what was said in the Daylight article about observations made near superior conjunction. M. Trouvelot thought that Venus should be as easy to the naked eye in full daylight, when only 5° from superior conjunction as when 10° from inferior conjunction. My reasons for thinking so too are given on pages 349-52. But when writing that article, the best reliable observation of this kind I had been able to make near any superior conjunction was made thirty-six days after the one in May, 1893, when the elongation was 10°. (p. 351.)

There have been two superior conjunctions since then, and at each of them a better observation than the above was made.

At Denver, Colorado, on October 30th, 1894, Mr. Roger Sprague saw Venus with the naked eye at 9.45 a. m. This was thirty-one days before the superior conjunction of November 30th. 1894. The angular distance was 7° 46′. Mr. Sprague says that the planet was "quite a difficult object to distinguish with the naked eye and required very persistent and careful looking to make it out at all." The difficulty of his observation led him to doubt the possibility of seeing Venus at all under the conditions that prevailed on July 6, 1892, Venus was five times as bright to him in October, 1894, as to me in July, 1892; she was nearly a degree farther from the sun; and Denver is 5000 feet nearer heaven and is blessed with a clearer atmosphere than Yarmouth. As the feat of seeing the planet was found extremely difficult under this fourfold set of favorable conditions, it was quite natural for the observer to think it impossible under the unfavorable conditions. I would think so too, had I not had experience of its possibility, and of the wonderful change that even a few minutes sometimes make in the seeing quality of the atmosphere or in the clearness of some particular patch of the sky. The clearest and purest blue is found between broken masses of cloud, and it was in such a swept and garnished bit of sky that I found Venus at her inferior conjunction in 1892. Another thing—she was 28° nearer my zenith then than she was to Mr. Sprague's zenith when he made his observation, and all observers know what a deal of difference that makes. Had he looked again an hour and a half later, when she was on his meridian, he would probably have found her—if his sky was clear—absurdly easy instead of extremely difficult.

Mr. Sprague's observation was the best one near superior conjunction that I had any record of up to that date.

The date of the next superior conjunction was July 9, 1896, at 9 a. m., 60° W. time.

To better the record, it was necessary to see Venus when less than thirty-one days from that date, and less than $7\frac{3}{4}°$ from the sun.

The thirty-first day before conjunction was June 8th. The midday sky was cloudy then, and so it was on the 9th, 10th, and 11th. On the 12th we had the pure blue sky that follows summer rain, and at noon my naked eye found Venus "disgrace fully easy." So my notes say. I suppose they mean it would have been disgraceful for even a bad eye (as was one of the two that made the observation) not to see her. They go on :—"Eye holds her dodging through clouds, and picks her up over and over again." This was twenty-seven days before conjunction. On the 13th, she was easier than on the 12th. Then there were nine days unfit for observation. On the 23rd, we had another of those glorious skies that follow a spell of rain and fog, and Venus was again easy, and was found very quickly after being located by a field-glass. On the 24th, she was not so easy, because the sky was white. On the 25th, the sky was fine, and my naked eye saw her for the last time before conjunction. It was fourteen days before, and the angular distance from the sun's centre was under 4°.

All the observations from June 12th to June 25th, were made between 12 and 12.30, (60° W. time), when Venus was very near the meridian, As the conjunction was a July one like the inferior conjunction of 1892—the very same day, indeed, July 9, in both cases—I had the advantage of high altitude.

This is likely my last note on this subject, and it may be as well to set down here a summary of the extreme observations which I have managed to make on Venus both with the naked eye and with an opera-glsss. A description of the glasses I used is given in the article cited, p. 354.

With naked eye :—

(*a*) At inferior conjunction—3 days before the conjunction of July 9, 1892. Elongation 6° 50′ from sun's centre. Altitude 64°.

(*b*) At superior conjunction,—14 days before the conjunction of July 9, 1896. Altitude 70°. Elongation, 3° 51′ from centre, 3° 35′ from limb.

Both of these observations were made within 15 minutes of mean noon.

(*c*) Near greatest elongation or greatest brilliancy,—April 30, 1892: found by eye when 18° above east horizon, the sun at the time being 44° high.

Angust 23, 1892: held by eye till only 8° above W. horizon, sun being over 35° high.

(Then there is the curious pair of observations already referred to—one after sunset on February 13, 1894, the other on the following morning before sunrise.)

With opera-glass or field-glass :—

(*a*) At inferior conjunction,—July 9, 1892: on the day and at the hour of conjunction. Elongation 4½°. Altitude 64°.

(*b*) At superior conjunction,—May, 11, 1893: 9 days after conjunction. Elongation 2¼° from limb. Altitude 64°.

December 12, 1894: 16 days after conjunction. Elongation 3¾°. Altitude 22.°

(*c*) Near greatest elongation or greatest brilliancy,—March 28, 1892: found when 7½° above East horizon. Sun's altitude 24½°.

August 23, 1892: held till only 3° above West horizon. Sun's altitude 29°.

YARMOUTH, N. S., *April 30, 1897.*

VI.—THE RAINFALL IN 1896. BY F. W. W. DOANE, M. CAN. SOC. C. E. CITY ENGINEER, *Halifax, N. S.*

(Read 10th May, 1897.)

The systematic and accurate registration of the rainfall is a matter of the greatest importance to the Engineer. It is absolutely necessary in order to enable him to design intelligently works for water supply, sewerage, water power, drainage of roads, bridges, culverts, &c.

He requires certain data to enable him to design dams spillways, storage reservoirs, sewers, bridges, &c., so that every possible requirement may be provided for.

The quantity of rain that falls annually in any one place varies greatly from year to year; the extreme being sometimes greater than 2 to 1. As a general rule, more rain falls in warm than in cold countries, and more in elevated regions than in low ones. Local peculiarities and conditions, however, sometimes reverse this, and also cause great difference in the amount in places quite near each other. It is sometimes difficult to account for these variations.

The earliest known records of rainfall were made in Paris in 1668. Sir Christopher Wren designed the first rain gauge in 1663. This great architect also designed the first recording gauge, but it was not constructed until 1670.

The rainfall records of some portions of the United States cover periods extending into the last century. In Canada, the average amount of rain falling in Ontario has been taken by the officials of the Magnetic Observatory at Toronto for the past 56 years. The meteorological station at Halifax was established in 1869, and observations began at Truro in 1873; a systematic registration of rainfall has been made at Yarmouth since 1879, and the record at Sydney dates back to 1893.

An examination of the records of the United States reveals some interesting and important facts, which it may be well to quote at this stage for the purpose of comparison.

The greatest annual rainfall on this continent is recorded at Greytown, the Atlantic entrance to the proposed Nicaragua Canal. It there assumes the enormous total of 240 inches (20 ft.), a figure which is only surpassed in the Western Hemisphere on the Mexican Gulf Coast in the West Indies, by Guiana and by the coast of Brazil. It is reported that from 7 to 10 per cent. of the total annual rainfall may descend in one day. The results of such a precipitation can be better imagined than described; dry river beds become torrents in a few minutes, the water coming down in a wall several feet high; marshes change to lakes, and the power so quickly developed is necessarily very dangerous to any work of man.

The most remarkable rainfall is recorded at Cuyamaca Dam in San Diego Co., California, about 40 miles east of San Diego. During a storm ending February 27, 1891, the record shows that 23.40 inches fell in 54 hours, of which 13 inches fell in 23 hours, and 7 inches in 10 hours. The elevation of the reservoir is about 4500 feet above sea level. The highest surrounding mountains are 6500 feet above sea level, and lie to the west of the reservoir between its watershed and the direction whence the storms come. The eastern boundary of the basin is on the rim of the desert at an elevation of not over 5000 ft. The topography of the country is such that a rain gauge at the dam would not be likely to indicate the maximum precipitation on the three peaks that bound the water shed on the west. The most notable thing about the above remarkable rainfall, however, is that the place where it occurred is within a few miles of one of the very driest regions in the world. The average annual rainfall at Indio, San Diego Co., a station on the Southern Pacific Railway, about 50 miles east of the Cuyamaca Dam, is given by General Greely as but 1.92 inches, and he says of this and Camp Mohave, Arizona, where the average rainfall is but 1.85 inches: " These stations, doubtless, have the smallest known

rainfall on the face of the globe. Statements have been made frequently that rain never falls in these localities, but there is no year at any station where a measurable rainfall has not been recorded, the least observed being that at Indio, 0.10 in., during the seasonal year 1884-85."

General Greely's "American Weather" gives the following instances of heavy rainfalls, which exceed the above record: Mayport, Fla., Sept. 29, 1882, 13.7 ins. in 24 hours; Newtown, Del. Co., Pa., Aug. 5, 1843, 13 in. in 3 hours; and at Brandywine, Hundred, Pa., 10 ins. in 2 hours.

Nevada Co., California, reports the rainfall for the month from Dec. 23, 1861, to Jan. 23, 1862, 45 ins. Providence, R. I., records a rainfall Aug. 6, 1878, 4.49 ins. in 1 hour, 3.5 ins. of which fell in 36 minutes. At New York, the heaviest fall is Aug. 19, 1893, 1½ ins. in 20 minutes; for 12 hours Aug. 23, 1893, 3.81 ins.; 24 hours Sept. 23-4, 1882, 6.17 ins.; month Sept., 1882, 14.51 ins.

The average annual rainfall at Halifax from 1869 to 1895 was 55.862 inches. It varies from 45.808 ins. in 1894 to 66.294 inches in 1888. A rainfall of 39.51 inches is reported for 1860, but as the Meteorological Observatory had not been established at that time, it is doubtful if the record is reliable. There is no doubt, however, that the rainfall for that year was far below the average. The scarcity of water, meagre supply from the lakes, and consequent inconvenience to householders lead to the purchase of the water works from the company in the following year, 1861.

Reference to the records shows that the years of smallest rainfall are immediately followed or preceded by years of greatest rainfall. Thus in 1888 the rainfall reached the maximum 66.294 inches. In the following year it dropped to 48.659, within 2.851 inches of the minimum. In 1894, as already noted, the season was very dry. The rainfall was the smallest recorded since the establishment of the Observatory at Halifax. The sources of our water supply dried up so that there was danger of a water famine. Similar conditions were noted throughout the New

England States. In the following year the records show a total of 62.152 inches, while in 1896 Mr. Allison, Dom. Government Meterological agent at Halifax, reports 69.862 inches, 3.568 ins. greater than that of any previous year. Rain or snow fell on 183 days. The greatest monthly rainfall on record previous to 1896 was 10.34 in February, 1870. In 1888 the heaviest monthly fall was 7.764, which is recorded in December. In 1896, 8.729 ins. fell in July, and 8.786 inches in March, while in September and October, the record shows 12.092 inches and 15.039 inches, respectively. Rain fell on 16 days in September, and on 20 days in October. The fall on the 7th, 10th, 13th and 18th of September, was 1.232 ins., 3.912 ins., 3.146 ins., and 1.510 inches, a total for the four days of 9.8 ins., or more than ¾ of the whole precipitation for the month. In October, 4.394 ins. fell on the 19th, 29 per cent. of the rainfall for the month, and 6 per cent. of the total for the year. The first month, January, gave the modest total of 1.72 inches, while for January, 1895, 10.131 inches is recorded.

There were four heavy storms during the year. Early in the morning of July 31st, rain began to fall, and during 3.8 hours the gauge showed 3.506 inches, or at the rate of .92 inches per hour. The rate of fall was the heaviest on record, although the quantity was exceeded in subsequent storms of greater duration.

On Sept. 10th, rain fell during 7.5 hours, the quantity registered being 3.912 ins., or at the rate of .52 ins. per hour, 0.186 inches fell on the 11th during 4.1 hours, 0.13 ins. on the 12th during 2 hours, and on the 13th, 3.146 ins. fell during 9.5 hours, or at the rate of .33 ins. per hour. The total fall for the four days was 7.374 inches. On October 19th the maximum quantity was recorded, the precipitation being 4.394 inches during 14.3 hours, or at the rate of .30 inches per hour.

The September rains referred to above raised Long Lake about 32 inches, the highest level reached being 10.5 inches above the waste weir. In October, the ground was saturated with

water, and the rain falling on the 19th flowed off rapidly. Long Lake was raised 20 inches by the heavy storm of the 19th in about 24 hours. The water level was 25 inches above the spillway of the dam, while at Lower Chain Lake it overflowed the screen chambers and ran over the floor of the old gate house. Drains and culverts were destroyed, roads washed out and bridges carried away. Jubilee Road was excavated by the rush of water for a length of 100 yards, the road metal being carried away for a width of half the roadway and a depth of 6 ft. Heavy stones were deposited at the foot of the hill, while the lighter material went to sea. The main trunk sewer on the common was not only full to overflowing, but a torrent of water followed its course on the surface, sweeping through the gardens and down South Park Street, until it found an outlet at South Street.

The Meteorological Agent at Truro reports about 30 hours rain on the 18th and 19th October, the greatest on record with regard to duration. At Yarmouth and Sydney the rain fall was light.

September 10th-13th, Sydney reports no rain; Yarmouth and Truro comparatively light rains. July 31st, moderate rainfall at Sydney, Truro and Yarmouth.

Comparing the Halifax records by months we find :—

July, 1896,	8.729 ins.	—next—	July, 1884,	8.294 ins.
Sept., 1896,	12.092 "	"	Sept. 1876,	6.094 "
Oct., 1896,	15.039 "	"	Oct., 1875,	9.98 "

Mr. E. H. Keating, City Engineer, says in making his report on a design for the Halifax sewer system :—

"The heaviest rainfall in a short time, of which I have any information, occurred on the 19th June, 1872, when 0.183 of an inch fell in half an hour."

He also reports a rainfall of 4.406 inches in 18 hours on the 10th October, 1875.

Our sewer system was designed to discharge a rainfall of 0.38 ins. per hour, together with the house sewage when running

two-thirds full. The designer made a liberal estimate in determining the capacity required, and yet during the past year it was plainly demonstrated that the capacity of the sewers was not sufficient to carry off the rainfall, and great trouble, damage and inconvenience has been caused in consequence. There is not the slightest doubt that the greater part, if not the whole, of this trouble would have been obviated if records of self-recording rain gauges had been available. While the greatest rainfall on record in 1876 was .183 inches in half an hour, we had in 1896 a storm lasting 7.5 hours, with an average rate of fall of .52 inches per hour, and another lasting 3.8 hours, with an average fall of .92 inches per hour. The maximum rate must have been greatly in excess of even the latter figure, but as the storm came n the dark hours of the morning, and the rain was not measured by self-registering instruments, we can only guess at the maximum rate per hour.

The design of sewers depends principally on two classes of storms. These are short storms of great rates of precipitation, and long storms of ordinary rates of precipitation. It is not sufficient to know the rainfall per hour. The severity of a storm often reaches a maximum during from 10 to 20 minutes only, and this maximum should be determined, if possible. It is also most important that the local conditions of the surface should be known. If the ground is saturated before the storm the rainfall will run off more rapidly.

A chief purpose to be subserved by a rainfall record is not merely how often does the maximum rainfall occur at each point, for that is an event which only occurs once or twice in a century. The great desideratum is: How often do the heaviest rainfalls of various rates occur, and for how long a maximum and average time does such a rainfall continue? The records from which such laws are deduced must necessarily be somewhat voluminous, and yet by proper study, aided by records of a number of years, a very close approximation to the real probabilities could be obtained and drawn graphically on charts, which would be of the greatest aid to hydraulic and city engineers; and even without

this, the bare records would give to a man who might be designing works at special points, material for digging out for himself some approach to a law where now all is guess work, and often very bad guess work.

It is to be regretted that the Meteorological Stations in this Province are not supplied with the most modern self-recording instruments. With an ordinary rain gauge it is not possible to determine the rate per hour of the fall of rain during a storm, without noting the time with a watch; and as it is very inconvenient, if not impracticable in the majority of cases to do this, it is very rarely done, and when it is, an average rate is all that is generally ascertained, although it may have been raining faster or slower at intervals during the time noted. By the use of a reliable self-recording rain gauge the different rates at which rain has fallen during a storm can be readily determined.

DEPTH OF RAINFALL AND MELTED SNOW, AND DURATION OF EACH STORM, FOR THE YEAR 1896.

Day of Month.	January.		February.		March.		April.		May.		June.	
	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.
1	......	....	......	....	......	....	......	....	......	....	0.180	1.5
2	......	....	0.440	20.	0.089	7.2	......	....	......	....	0.020	....
3	0.065	1.75	*T.	....	0.094	3.5	0.889	5.6	......	....	......	....
4	......	....	......	....	0.510	6.7	0.015	1.	......	....	......	....
5	......	....	......	....	0.186	4.	0.323	6.5	0.106	2.0	......	....
6	......	....	T.	....	......	....	0.012	0.5	0.050	2.0	0.020	0.5
7	......	....	1.310	14.	0.030	1.6	......	....	......	....	......	....
8	......	....	......	....	0.596	7.	......	....	......	....	......	....
9	......	....	0.010	1.	......	....	......	....	T	....	0.770	10.1
10	0.660	10.5	0.342	6.5	......	....	......	....	T.	....	0.970	11.3
11	0.030	2.5	0.480	3.	0.030	1.1	......	....	......	....	0.090	2.3
12	......	....	0.100	1.	1.619	15.	......	....	0.130	0.5	0.444	8.5
13	0.040	1.5	0.020	1.7	......	....	......	....	......	....	......	....
14	0.140	4.66	0.522	7.75	......	....	0.009	1.0	......	....	T.	....
15	T.	....	......	....	......	....	0.034	2.0	......	....	0.841	14.5
16	0.020	10.	0.260	6.5	0.040	2.	T.	....	......	....	0.086	3.
17	......	....	......	....	1.655	13.5	0.040	2.5	......	....	......	....
18	......	....	0.010	1.	......	....	0.015	2.0	0.250	1.0	0.010	0.5
19	......	....	0.220	5.2	0.020	0.8	0.020	0.8	0.068	3.0	......	....
20	......	....	0.410	8.3	1.498	9.4	0.010	1.0	0 210	3.5	0.050	1.5
21	......	....	......	....	......	....	......	....	......	....	......	....
22	0.050	7.5	......	....	......	....	..	....	0.305	5.8	0.060	1.7
23	......	....	......	....	......	....	......	....	0.186	0.5	......	..
24	......	....	0.075	2.	......	....	......	....	....	....	......	....
25	0.390	10.	......	....	......	....	......	....	......	....	......	....
26	0.270	12.5	......	....	0.192	1.7	......	...	......	....	0.230	4.0
27	0.045	1.75	......	....	1.450	8.5	......	....	0.247	3.0	0.200	3.7
28	0.010	....	......	....	......	....	......	....	0.014	....	......	....
29	......	....	......	....	......	....	0.046	..	0.540	2.7	0.700	8.3
30	......	....	......	....	0.274	8.2	......	....	0.426	6.0	......	....
31	......	....	......	..	0.503	7.3	......	....	......	....	......	....
	1.720	....	4.199	....	8.786	....	1.413	....	2.532	...	4.671	....

* Trace.

Depth of Rainfall and Melted Snow, and Duration of each Storm, for the Year 1896.

Day of Month.	July.		August.		September.		October.		November.		December.	
	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.
1	.....	....	......	....	.....	....	2.352	10 4	0.005	0.4	0.020	0.5
2	.....	....	0.354	5.0	......	....	0.764	9.5	0.170	6.6	......	....
3	....	....	0.378	5.0	......	....	0.552	8.7	0.032	1.0	...	....
4	T.	....	....	....	0.112	3 8	0 010	1.5	.....	....	T.	....
5	0.938	11.0	......	....	......	....	....	....	..	....	0.362	5.3
6	......	....	......	....	......	....	0 685	11.2	0.824	10.1	...	....
7	0.664	6.0	0.102	8.0	1.232	12.5	0.312	24.	T.	....	......	....
8	0.306	3.0	0.010	1.0	0.030	1.0	0.230	6.5	......	....	......	...
9	......	....	......	....	..	....	....	....	0.853	6.5	1.524	13.3
10	......	....	0 010	....	3.912	7.5	.....	....	0.036	0 3	0.020	0.8
11	....	....	......	....	0.186	4.1	......	..	0.033	2.0	T.	....
12	.....	...	T.	...	0.130	2.0	......	....	0.682	5 5	......	....
13	......	....	T.	...	3.146	9.5	0.756	10 0	T.	....	0.020	1.0
14	0.170	3.3	T.	....	......	...	1.597	12.2	0.207	7.3	......	....
15	0.062	1.2	.....	...	......	....	0.125	12.0	T.	....	.....	..
16	0.220	5.0	0.250	5.5	......	....	0.022	6.1	0 071	3.0	0 450	9 7
17	T.	....	0.082	3.0	0.302	4.0	......	....	.....	....	0.150	2.5
18	.....	....	......	...	1.510	4.5	0 823	10.4	......	....	.....	...
19	......	...	0.034	1.7	0.546	4.5	4.394	14.3	0.020	1.5	0.692	8.0
20	.....	....	0.060	0.9	0.507	..	......	....	.....	...	......	....
21	0.670	11.0	....	....	T.	..	......	....	0.010	0.1	......	....
22	......	....	......	....	0.041	1.5	0.372	5.2	0.732	7.5	......	....
23	1.041	12.8	......	....	0.405	5 8	....	....	...	....	......	....
24	.....	....	1.372	8.4	.....	....	0.562	6.0	0.178	9.4	...	....
25	0.568	8.0	......	....	......	....	1.007	8.0	.....	....	......	....
26	.....	....	......	....	......	....	....	....	0.130	13 0	0.010	3.2
27	.....	....	0.333	5.4	......	....	0.010	0.4	0.121	6.3	.....	....
28	0.584	7.0	0.052	3.8	0.033	0.2	......	....	......	....	......	....
29	.....	...	....	....	......	....	0.109	3.0	0 202	6 3	... ..	....
30	....	....	....	....	T.	....	0.227	18.2	0.090	5 0	....	....
31	3.506	3.8	T.	..	.. ..	....	0.130	4.1	......	....	T.	....
	8.729	....	3.037	....	12.092	....	15.039	....	4.396	....	3.248	...

TOTAL PRECIPITATION AT HALIFAX, N. S.

Compiled from Returns furnished by the Meteorological Agent of the Dominion Government.

MONTH.	1869.	1870	1871.	1872.	1873.	1874	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
January	4.53	7.11	3 73	3.88	7.83	5.42	3 94	3.576	4 200	7.534	4 400	7.738	3.607	6.840
February	4 38	10.34	5 88	4.49	1.61	5.31	5 83	6.401	1.809	2.697	3.001	5 122	5.329	5.949
March	7.95	3.02	6 16	5 37	4 09	3.98	2.13	6.329	8.666	10.274	6.044	3.365	6 556	7.068
April	2.57	3.91	4 88	2.85	2 86	4.55	3 38	3.208	3.801	3.452	3.481	4 797	3.498	4.824
May..............	5.57	3.19	2 59	4.44	2.34	4 77	3.98	5 662	4.024	5.769	4.687	4.088	2.460	4.677
June	3 92	1.69	2.96	4 23	2 96	7.92	4.07	3 376	3 841	4 477	1.191	1.343	5 301	5.507
July..............	2.92	3 21	3.38	2 88	3.90	2.29	5.61	3.914	4.468	1.483	3.843	3.086	3.177	5.071
August	2.58	2.20	3 69	6.82	4.45	3.37	3 55	1.909	3.539	3.127	4.827	3.920	3.062	3 925
September	1.57	3.33	4.81	1 41	4.48	5.04	2.06	6.094	3.164	.800	2.600	5.702	3 105	5.914
October	7.30	6.85	4.49	4 88	8 63	2.46	9.98	4 076	6.857	5.060	4.760	4.590	4.206	7.403
November	5.47	6.28	4.18	6 65	7.98	3.58	5.54	7.397	8.678	6 909	4 837	4.710	4.420	1.392
December	5.77	6.06	4.39	6.16	4 31	5.49	1.61	3.164	4.493	5.120	4.029	4 291	7.034	3.452
Totals	54.53	57.19	51 14	54.06	55.44	54.18	51 48	55.106	57.540	56 702	47.700	52.752	51.755	62.022

TOTAL PRECIPITATION AT HALIFAX, N. S.—(*Continued*).

MONTH.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
January	6.930	4.406	6.388	8.67	7.656	5.442	4.391	3.963	8.383	6.321	4.781	7.122	10.131	1.720
February	3.860	6.161	5 090	3.84	6.735	6.284	6.181	4.645	8 740	2.605	5 979	3.571	4.605	4.199
March	4.941	7.034	3.889	4.03	4.629	4.310	2.046	9 889	2 685	5.986	2.303	3.623	5.931	8.786
April	3.703	7.213	3.520	0.82	6.386	3.675	7.403	2 958	4 010	2 653	4 209	5 648	3.956	1.413
May	8.613	3.629	3.282	8.82	2.126	2.877	3.871	3 970	4.195	5.459	5 054	1.769	4.089	2.532
June	3.322	3.773	2.749	2.71	2.121	4.939	3.755	3 440	4.131	3.638	1.753	3.803	1.827	4.671
July	3.542	8.294	5.817	6.53	2.045	5.001	2.668	2.141	4.003	2.710	4.757	1.059	3.924	8.729
August	5.342	2.771	3.001	4.53	8 351	7.000	2 633	7.042	3 385	6 809	5.954	3.993	5.502	3.037
September	3.864	1.788	2.497	4.46	3.308	5.331	1.399	4.534	3 052	1.744	4.391	1.010	2.491	12.092
October	5 841	3.093	6.280	2.13	3.058	6 859	4.179	6.603	9 621	3.492	5.640	3 863	5.627	15.039
November	5.478	5.992	5.423	5.28	6 718	6.772	7.145	3.716	2.388	9.240	3.760	5.785	8.223	4.396
December	6.678	9.124	8.693	5.47	4.120	7.764	2.988	7.202	4.076	3 053	10.167	4.562	5.846	3 248
Totals ...	58.112	63.278	56.629	57.29	57.253	66.294	48.659	60 103	58.669	53.690	58.748	45.808	62.152	69 862

PRECIPITATION AT TRURO IN 1896.

MONTH.	Rainfall	Melted Snow.	TOTAL.
January	0 07	2.3	2.37 inches.
February	0.12	1.5	1.62 "
March	4.11	1.0	5 11 "
April	0.60	0 5	1.10 "
May	1.45	....	1.45 "
June	3.44	....	3.44 "
July	6 19	....	6.19 "
August	2.24	....	2 24 "
September	5 01	....	5.01 "
October	11 47	....	11.47 "
November	2.58	0 62	3.20 "
December	1.49	0.65	2.14 "
Totals	38.77	6 57	45.34 inches.
July 31	0.44	....	
Sept. 10-11	0 33	....	
" 13	0.35	....	
Oct. 1-3	4.65	....	
" 18-19	4 02	....	
Average rainfall for October, for 23 years	4 51	....	
Average precipitation for 17 years.	43.85	....	

PRECIPITATION AT YARMOUTH.

July	19-25,	1896	2.02
"	30-31,	"	0.58
Aug.	23-24,	"	2.45
Sept.	6-7,	"	0.91
"	13-14,	"	0.48
Oct.	1-2,	"	0.12
"	18-19,	"	0 04
"	23-24,	"	1.97

Heaviest recorded rain, 4.16 inches, August 5th, 1885, in 8 hours.
Greatest precipitation in a month, 10.7 inches, October, 1888.
Total in 1888, 71.57 inches, 22.5 above the average.

PRECIPITATION AT SYDNEY.

July	31,	1896	0.60
Sept.	10,	"	0 00
"	13,	"	0.00
Oct.	1,	"	1.76
"	19,	"	0.54

Heaviest rain on record, 2.04 inches, August 17th, 1893.

Date of publication of Vol. IX, Part 3: November 30th, 1897.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1897-98.

I.—On the Calculation of the Conductivity of Aqueous Solutions containing Potassium and Sodium Sulphates.—By E. H. Archibald, B. Sc., *Dalhousie College, Halifax, N. S.*

(Read November 15th, 1897.)

According to the dissociation theory of electrolysis, held by Arrhenius and others, the conductivity of a mixture of two solutions of electrolytes, 1 and 2, which have one ion in common, and which contain n_1 and n_2 gramme-equivalents per unit of volume, is given by the expression:

$$\frac{1}{p(v_1+v_2)}\left(\alpha_1 \, n_1 \, \mu_{\infty 1} \, v_1 + \alpha_2 \, n_2 \, \mu_{\infty 2} \, v_2\right),$$

where v_1 and v_2 are the volumes of the two solutions mixed, p the ratio of the volume of the mixture to the sum of the volumes of the constituent solutions, $\mu_{\infty 1}$ and $\mu_{\infty 2}$ the molecular conductivities, at infinite dilution, of the respective electrolytes under the conditions in which they exist in the mixture, and α_1, α_2, the ionization coefficients of the respective electrolytes in the mixture.

The value of p in the above formula may be determined by density measurements, before and after mixing; $\mu_{\infty 1}$ and $\mu_{\infty 2}$ which for sufficiently dilute mixtures, may be considered to have

the same values in the mixture as in the simple solutions, may be determined by conductivity measurements, to great dilution, of each electrolyte; and n_1 and n_2 may be determined by analysis. Provided, therefore, we can find the value of α_1 and α_2 the conductivity can be calculated.

In a paper communicated to this society in 1896, Professor MacGregor* explained a method for the determination of the α's in the above formula. He applied this method to some mixtures of solutions of Sodium and Potassium Chloride, examined by Bender, and found it possible to calculate their conductivity when they contained less than two gramme-molecules per litre, within the limits of experimental error. For more concentrated mixtures he found the observed values to be greater than the calculated, and the difference to increase with the concentration, till at a concentration of four gramme-molecules per litre the difference was between 3 and 4 per cent. The conductivities of mixtures of Sodium and Hydrogen Chloride solutions were measured and calculated by D. McIntosh,† who found that the conductivity of these mixtures could be calculated, within the limits of experimental error, up to a mean concentration of about one gramme-molecule per litre, and that for a mean concentration greater than this, the calculated value was greater than the observed.

The measurements, described below, were undertaken with the view of ascertaining if the conductivity was calculable, in the case of mixtures of solutions of Potassium and Sodium Sulphates, salts of more complex molecular structure than those previously examined. They were conducted in the Physical and Chemical Laboratories of Dalhousie College.

The work included purification of the salts, and of water; preparation and analysis of a series of simple solutions, and determination of their conductivity; plotting curves, giving the relation of concentration of ions to dilution for these simple solutions; preparation of the mixtures, and measuring and calculating their conductivity.

* Transactions N. S. Inst. Science, IX (1896), p. 101.
† Transactions N. S. Inst. Science, IX (1896), p. 120.

Purification of the Salts.

The salts were obtained as chemically pure from Eimer and Amend of New York. They were carefully re-crystallized three times. After being thus treated, no impurities to any extent could be detected.

Purification of the Water.

The water used was purified by the method described by Hulett,* except that a block tin condenser was used instead of a platinum one. Water, purified by this method, had a conductivity at 18°C, varying from 0.85×10^{-10} to 0.98×10^{-10}, expressed in terms of the conductivity of mercury at 0°C. It was kept in bottles which had been used for this purpose for several years. It was neutral and left no residue on evaporation.

Preparation and Analysis of Simple Solutions.

The method adopted was to make up as concentrated a solution as it was desired to measure. This solution was carefully analysed, and from it successive multiple dilutions were prepared by adding water, all solutions being prepared at a temperature of 18°C.

A volume of fifty cubic centimetres of these solutions would be introduced into the electrolytic cell, and successive dilutions prepared from this in the cell itself, by withdrawal of a certain volume, and addition of an equal volume of water. As a check upon errors of dilution, after a portion had gone through a number of dilutions, it was taken from the cell and carefully analysed, and, if found necessary, the previous determinations of the concentration were corrected from these results.

The concentration of the solutions was determined by gravimetric analysis, the quantity of salt in solution being estimated from the amount of Barium Sulphate precipitated by Barium Chloride, when added in slight excess to a known

* Journ. Phys. Chem., Vol. I, p. 91.

volume of the solution to be analysed. The following results will show with what accuracy such analyses could be carried out:—

(1.)	K_2SO_4 in 5c.c. of solution	=	0.2174	gram.
(2.)	" " "	=	0.2178	"
(3.)	" " "	=	0.2179	"
	Mean	=	0.2177	"
(1.)	Na_2SO_4 in 5c.c. of solution	=	0.2365	"
(2.)	" " "	=	0.2369	"
(3.)	" " "	=	0.2370	"
	Mean	=	0.2368	"

It would seem that the result might be in error by about 0.14 per cent.

In the case of the Potassium Sulphate, standard solutions were made up from weighed quantities of the salt, which had been dried to constant weight in an air bath.

Preparation of the Mixtures.

For convenience in calculating, the mixtures were made up of equal volumes of the constituent solutions. All mixtures were prepared at a temperature of 18°C, the constituent solutions being kept, for about 20 minutes previously to mixing, in a water bath, the temperature of which was kept as near 18°C as possible, by means of a thermostat. A 50 c.c. pipette was used to measure out the volumes; the same pipette being used for both solutions, and care being taken to use the pipette in the same manner in both cases. During outflow, the point of the pipette was allowed to rest against the side of the vessel, and when outflow had ceased it was slightly blown into without removing the point.

All pipettes used were calibrated by weighing the water they delivered. None were used in the experiments, in which the time of outflow was less than 40 seconds.

Determination of the Conductivity.

The Kohlrausch method with the telephone and alternating current was used. The measuring apparatus consisted of four resistance coils, and a german-silver bridge wire, about three metres long, wound on a marble drum. The wire was divided into 1000 parts, and had a resistance of about 1.14 ohms. It was calibrated by the method of Strouhal and Barus,* the corrections thus obtained being plotted against length on co-ordinate paper, and the correction for any point on the wire taken off this curve.

The resistance coils were marked 1, 10, 100, and 1000 ohms. As I used only one coil (that of 1000 ohms), and as it was not necessary to express the conductivities in absolute measure, I did not need to know the relative accuracy of the coils, or the absolute value of the one used.

Two electrolytic cells were used, one for solutions more concentrated than 0.1 equivalent gramme-molecules per litre, the other for solutions more dilute. They were of the U-form, shown by Ostwald in his Physico-Chemical Measurements, page 226, fig. 178.

The electrodes were of stout platinum foil, not easily bent, circular in form, and about 3.5 cm. in diameter. Care was taken to have the electrodes always in as nearly the same position in the electrolytic cell as possible. No change of resistance could be observed for small differences in position, such as could be detected by the eye, and avoided.

The induction coil was small, and had a very rapid vibrator. It was kept in a box stuffed with cotton wool, that the noise might not interfere with the determination of the sound minimum in the telephone. A Leclanché cell was found most convenient for working the coil. With this arrangement the minimum point on the bridge-wire could be determined to within 0.3 of a division. This would allow an error of 0.12 per cent in the determination of the resistance at the centre of the bridge,

* Wied. Ann., x (1880), p. 326.

and 0.15 per cent at the point farthest from the centre, used in my experiments.

Platinizing the Electrodes.

The electrodes, after being washed in boiling alkali and acid, were placed in a solution prepared from a recipe given by Lummer and Kurlbaum, and referred to by Kohlrausch.* This solution consists of 1 part platinum chloride, 0.008 of acetate of lead, and 30 of water. They were then connected with the terminals of two Bunsen cells arranged in series, the direction of the current being frequently changed. When the electrodes had become covered with a velvety coating of platinum black, they were removed from the solution and thoroughly washed with boiling water to remove all traces of the chloroplatinic acid. The platinizing can be done much more quickly with the above solution than with the chloroplatinic acid alone.

Reduction Factor.

To find the factor, which would reduce the observed conductivities to the standard employed by Kohlrausch, (the conductivity of mercury at 0.C), the values of the conductivity for a series of solutions of each salt, which were measured for the purposes of calculation, were plotted against the concentration (gramme-equivalents per litre), and conductivities corresponding to the concentrations examined by Kohlrausch, taken off these curves and compared with the values given by him. The ratio of these values was found to be practically constant for each salt through as wide a range of dilution as it was necessary for me to measure.

Temperature.

All conductivity measurements were made at 18°C. To insure this condition, the cell containing the solution to be measured was placed in a water-bath, the temperature of which was regulated by a thermostat, of the form recommended by Ostwald in his Physico-Chemical Measurements, p. 59, fig. 42. The regulating liquid, which was water, was enclosed in a brass

* Wied. Ann., LX (1897), p. 315.

tube, about 35 cm. long and 4 cm. in diameter, bent so as to form three sides of a square. Two vanes fixed at an angle of 45° near the bottom of the bath, to a vertical axis, which was turned by a small hydraulic motor, kept the water of the bath well stirred. The thermometer used was graduated to fiftieths of a degree, and could easily be read to hundredths. Its readings were compared with those of another, whose errors had recently been determined to hundredths of a degree at the Physikalisch-Technische Reichsanstalt, Berlin. With this apparatus the temperature of the bath could be kept constant to within a fiftieth of a degree, for half an hour at a time. A variation of one-fiftieth of a degree might cause an error of 0.05 per cent in the determination of the resistance.

That one might be sure that the temperature of the solution to be measured had come to be that of the bath, two or more determinations of the resistance were always made at intervals of about five minutes, and that reading taken which was found to be the same for successive intervals.

Data for the Calculations.

For the simple solutions the ionization coefficient (α) was taken to be equal to the ratio of the specific molecular conductivity to the specific molecular conductivity at infinite dilution. Kohlrausch's values for the specific molecular conductivity at infinite dilution were used. They were taken to be 1280×10^{-8} and 1060×10^{-8} for Potassium and Sodium Sulphate respectively, as determined by him.*

The value of p in the above formula was found by density measurements before and after mixing. These measurements were carried out with Ostwald's form of Sprengel's pyknometer. Measurements, accurate to one in the fourth place of decimals, which was beyond the degree of accuracy required, could be made without much difficulty. The value of p was found to be practically equal to unity for the most concentrated solutions examined.

* Wied. Ann., Vol. XXVI., p. 204.

Results of Observations on Simple Solutions.

For the purposes of calculation it was necessary to draw curves for each salt, showing the relation of dilution to ionic concentration. It was therefore necessary to know the concentrations and conductivities of a sufficiently extended series of dilutions of each salt. The following table gives the dilution, conductivity, and concentration of ions of each solution examined.

Potassium Sulphate.			Sodium Sulphate.		
Dilution.	Conductivity.	Concentration of ions.	Dilution.	Conductivity.	Concentration of ions.
20.00	959	.0375	20.00	784	.0370
15.62	934	.0467	15.62	771	.0466
12.50	918	.0574	12.50	753	.0568
10.00	898	.0702	10.00	734	.0692
8.605	893	.0811	7.047	663	.0888
7.173	879	.0957	5.882	651	.1044
5.973	856	.1119	5.313	648	.1150
4.977	839	.1316	3.692	623	.1592
3.456	791	.1787	2.918	598	.1933
2.880	771	.209	2.431	583	.226
2.400	753	.245	2.022	562	.262
2.073	741	.279	1.689	541	.302
2.000	737	.288	1.408	521	.349
1.440	707	.384	1.176	496	.397
1.200	689	.449	1.016	478	.443
1.000	672	.525	.847	456	.507

The dilutions are expressed in terms of litres per equivalent gramme-molecule at 18°C. The conductivities are specific mole-

cular conductivities at 18°C, expressed in terms of 10^{-8} times the specific conductivity of mercury at 0°C. The concentrations of ions are the ratios of the specific molecular conductivity to specific molecular conductivity at infinite dilution, divided by the dilution.

Results of Observations on Mixtures.

The following table contains both the data for, and the results of, the calculation of the conductivity of each mixture examined.

Concentration of the Constituent Solutions.		Concentration of ions in the Mixture.	Dilution in the Mixture.		Conductivity of Mixture.		
$\frac{1}{2}K_2SO_4$.	$\frac{1}{2}Na_2SO_4$.		$\frac{1}{2}K_2SO_4$.	$\frac{1}{2}Na_2SO_4$.	Calculated.	Observed.	Difference per cent.
1.000	2.000	.637	.7940	.6030	746.0	735.0	+1.47
.8263	"	.605	.8463	.6510	707.2	699.7	+1.06
.9915	1.998	.635	.7959	.6050	743.4	738.4	+0.67
"	1.667	.588	.8742	.6790	687.7	682.9	+0.68
"	1.427	.554	.9441	.7440	648.0	645.4	+0.40
"	.9982	.482	1.096	.9060	564.7	565.9	-0.21
.4957	.9975	.3760	1.473	1.272	438.5	436.8	+0.38
"	.6658	.3105	1.837	1.634	363.6	364.4	-0.21
"	.4996	.2740	2.112	1.908	320.9	322.1	-0.37
.4166	.5050	.2572	2.281	2.077	300.6	301.2	-0.19
.3333	"	.2360	2.509	2.304	276.0	275.5	+0.18
.2500	"	.2141	2.795	2.576	250.3	249.5	+0.31
"	.2525	.1544	4.121	3.840	180.5	180.9	-0.22
"	.1683	.1332	4.933	4.554	155.7	155.2	+0.32
"	.1262	.1210	5.463	5.024	141.5	141.3	+0.14
.1000	.1010	.0700	10.02	9.870	81.89	81.90	-0.01
"	.0800	.0631	11.18	11.03	73.81	73.71	+0.13
"	.06734	.0598	12.01	11.86	69.96	70.05	-0.12
"	.05050	.0542	13.33	13.20	63.40	63.49	-0.14
.04000	"	.03485	22.28	21.95	40.76	40.83	-0.17
.02500	"	.02860	26.96	26.25	33.45	33.36	+0.26
.01500	"	.02570	30.63	30.50	30.05	30.12	-0.23

The concentrations of solutions are expressed in terms of equivalent gramme-molecules per litre at 18°C. The conductivities are specific conductivities at 18°C expressed in terms of 10^{-8} times the specific conductivity of mercury at 0°C. The concentration of ions (column 3) common to the two electrolytes in the mixture and the dilutions of the electrolytes in the mixture (columns 4 and 5) are obtained by Prof. MacGregor's graphical process.* The former is the number of dissociated gramme-equivalents of either electrolyte present in the mixture, divided by the volume in litres of the portion of the solution occupied by it. In any one mixture it has the same value for both electrolytes. The latter are the volumes in litres of the portions of the solution occupied by the respective electrolytes divided by the numbers of gramme-equivalents present. In each mixture they have different values for the two electrolytes. The product of the former into the value of the latter in the case of either electrolyte gives the ionization coefficient for that electrolyte in the mixture.

It will be seen from the above table that the differences range from 1.47 per cent to 0.12 per cent. that the greater differences are for the stronger solutions, and that in the case of these solutions all the differences but one have the same sign.

For more dilute mixtures than 0.7 equivalent gramme-molecules per litre, the differences are within or but little beyond the limit of the error of an observation, which would be about 0.25 per cent. The sign also changes frequently. The differences in these cases are therefore probably due to accidental errors.

In the case of the stronger solutions, it was to be expected that the differences would be beyond the limit of error, as the ionization coefficients (α) were taken to be the ratios of the specific molecular conductivity to the specific molecular conductivity at infinite dilution, and this is rigorously true only for infinitely dilute solutions. Also the value of the specific molecular conductivity at infinite dilution for an elecrolyte in a

* *Loc. cit.*, p. 108.

mixture can be taken to be exactly the same as the value found by observations on the simple solutions only in the case of infinitely dilute mixtures.

The fact that for mixtures of nearly saturated solutions of these salts, the difference between the calculated and observed values is only 1.47 per cent, while for solutions of KCl and NaCl as near saturation, the difference is about 5 per cent, as determined by MacGregor* and again by McIntosh*, would seem to indicate that in the case of this class of salts, the magnitude of the differences depends on the amount of salt in the solution, not on the nearness to saturation.

It would appear from the above results that for mixtures of solutions of these salts not more concentrated than 0.8 equivalent gramme-molecules per litre, it is possible, by the aid of the dissociation theory, to calculate the conductivity within, or but little beyond, the limit of the error of observation.

**Loc. cit.*

II.—REMARKS ON SOME FEATURES OF THE KENTUCKY FLORA.

By THE LATE PROFESSOR GEORGE LAWSON, LL. D.,* *of Dalhousie College, Halifax, N. S.*

(Read December 11th, 1893.)

Having received a set of the extensive collection of plants made in the south-eastern part of the State of Kentucky during the past summer by Mr. T. H. Kearney, Jr., of the Botanical Department of Columbia College, New York, Dr. Lawson embraced the opportunity to show some of the more remarkable species to the members of the Institute, and to point out some of the prominent resemblances and differences in feature between the Kentucky and Eastern Canadian floras.

The most striking feature of the Kentucky flora to a Nova Scotian or Eastern Canadian botanist, is the presence of noble arboreous forms that do not extend northerly so as to spread into Canada, and others that only touch its southern limits, about Lake Erie and the western part of Lake Ontario. Such southern forms, represented in Mr. Kearney's collection, are seen specially in the magnificent magnolias, of which three species were shown, viz., *Magnolia Fraseri*, *M. macrophylla*, with leaves a foot or more in length, and *M. tripetala*. These are the remnants of a genus at one time widely spread over the American continent, as shown by comparatively abundant fossil remains that have been found even in the arctic regions, but which in later time, presumably as the result of climatic change, retreated to the south. The specimens of the last named species had ripe fruit, with the remarkable pendent seeds, the nature of the thread-like connection between the fruit and seeds being described and illustrated by figures from Schnitzlein's Iconographia and the American Sylva.

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* This short account of a communication made to the Institute by the late Professor Lawson, on the 11th December, 1893, and never completely elaborated, has been found among his manuscripts. Though written for insertion in the Proceedings, it is printed here without change.

The following synonymy of these magnolias is gleaned from Index Kewensis, vol. iii:—

Magnolia Fraseri, Walt. Fl. Carol., p. 159. *M. auricularis*, Salisb. Parad. Lond., t. 43. *M. auriculata*, Desr. in Lamarck's Ency. iii, p. 673. *M. pyramidata*, Bartram ex Pursh Fl. Am. Septent, ii, p. 382.

M. macrophylla, Michaux, Fl. Bor. Am., I, p. 328. *M. Michauxiana*, Hort. ex D. C. Syst., I, p. 455.

M. Umbrella, Desr. in Lamarck's Encyc., iii, p. 673 Hook. and Jacks, Ind. Kew., p. 146, 1. *M. frondosa*, Salisbury, Prod., p. 379. *M. Umbellata*, Hort. ex Stendel, Nom. ed. 2, ii, p. 90. *M. Virginiana*, Linn. Sp. Pl., 535 = (*acuminata, glauca, Umbrella*). *M. tripetala*, Linn. Syst., ed. 10, p. 1082.

The Kentucky Oaks shown were of three species, *Quercus alba*, valuable for its timber; *Q. Prinos*, called chestnnt oak from the resemblance of its leaves to the true (not horse) chestnut (*Castanea*), and whose thick furrowed bark is used for tanning; and, lastly, *Q. tinctoria*, the quercitron oak, which, as the name indicates, is used by the dyer as well as the tanner.

The southern beech (*Fagus atropunicea*), although obviously related to our Canadian *F. ferruginea*, which forms the bulk of the original hardwood forest in many parts of Nova Scotia, is nevertheless quite a different tree, and instead of having a more ample foliage, as we might expect in the southern form, has even smaller leaves than ours. The European beech, *F. sylvatica*, was probably as abundant in western Europe in early times as our Canadian beech is still along the Atlantic seaboard, and it is difficult to separate it as a species.

The only maple in the collection is *Acer Rugelii*.

The red-bud, or Judas tree, was named *Cercis Canadensis* by Linnæus at a time when the geographical limits of "Canada" were rather vague. New York State embraces its most northerly range.

Kalmia latifolia, also, must be relegated as a southern (although a mountain) plant. From its northern range in the

United States, it seems difficult for American botanists to realize that it does not extend into Canada through some of the valleys that connect the two countries. It was attributed to Canada by Michaux. Like the *Cercis*, it was included in Hooker's *Flora Boreali-Americana*, an authority of Pursh; and even in Dr. Asa Gray's last and greatest work, the Synoptical Flora, it was recognized as Canadian. The fact is, however, that we have no actual evidence of the occurrence of this species in British America. The only definite record to the contrary is that of Mr. B. Billings, Jr., who thirty years ago included the name in a list of Prescott Plants published in the Annals of the Botanical Society of Canada. Mr. B., however, found, some some years later, that he had mistaken a broad-leaved form of *K. angustifolia* for the more southern species. That the southern limitation of certain woody plants is not due to unsuitable climatal conditions in the north at the present time is shown by the readiness with which such plants grow when planted, as in the case of the southern *Rhododendron Catawbiense*, which has flourished in a remarkable manner at Lucyfield, near Halifax, growing freely, and forming thickets of from ten to fifteen feet in height, blossoming abundantly, and spreading itself by seed to adjoining grounds. Indeed it is a much more robust plant and more rapid grower than the native *R. maximum*, which seems to be now almost extinct in Nova Scotia, and to have become very rare in the Province of Quebec. At Lucyfield, *Rhododendron ponticum* has not survived, although large numbers have been planted, while *Azalea pontica* that grows with it in beech woods in the Caucasus, is perfectly hardy and grows as vigorously as any native bush.

Of other plants in Mr. Kearney's collection may be noticed the oil nut, *Pyrularia pubera*; sassafras (the *Laurus Sassafras* of Linnæus, *Sassafras officinale* of Nees and Esenbeck, and of the forthcoming volume of Hortus Kewensis), the fruit as well as the bark of the root of which yields sassafras oil. This species, although indicated in books such as Lindley's Flora Medica, as growing generally in "woods of North America from Canada to

Florida," is really essentially southern in its range, occurring sparingly on the banks of the Humber near Toronto, (only one bush six or seven feet high was seen in 1860,) and a few other favoured spots in the extreme southern parts of the Province of Ontario.

There is also the spice-bush, *Lindera Benzoin*, of Meissner in DeCandolle's Prodromus, and of Hortus Kewensis, iii, p. 89, located in the latter as "Am. Bor." This is not Adamson's genus *Lindera* (1763), now referred to *Myrrhis*, Tourn., (Umbelliferæ), but that established later by Thunberg, Diss. Nov. Gen., iii, p. 44, (1783). This is the *Laurus Benzoin* of Linnæus, Sp. Plantarum, p. 370, amplified by Michaux in the Fl. Bor. Am. into *L. pseudo-Benzoin*, for the obvious purpose of preventing confusion of this lauraceous plant with a conspicuous one belonging to the Styracaceæ, viz., the Siamese *Styrax Benzoin* of Dryander (Phil. Trans., lxxvii, 308, t. 12,) which yields gum benzoin, and was called *Benzoin officinale* by Hayne. (Buchanan-Hamilton used the name *Laurus Benzoin*, according to Wallich's Catalogue of Indian plants, for *Cinnamomum obtusifolium*).

Our American plant, which forms a bush from eight to ten feet high, was named *Benzoin odoriferum* by Nees von Esenbeck (Laurin., 497). The berries yield an aromatic oil; the wood and bark are also highly aromatic, and, as this plant is said to have been used in the United States during the first American war, as a substitute for allspice, it may be responsible for the American tradition of wooden nutmegs. It is known by the several names of spice-bush, spice-wood, spice-berry, fever-wood, &c. Dr. Lindley, in Flora Medica, indicates its range thus: Low moist places, damp shady woods, from Canada to Florida.

Rhus copallina, Sumach.

Azalea lutea.

Vitis aestivalis.—The Summer Grape. The bunches bore bunches of ripe fruit, from the seeds of which plants are being raised for comparison with more northern forms.

Ilex opaca.—The American Holly, a species that closely resembles in habit, its bright shining evergreen foliage, the

English Holly, with which it is often cultivated in English gardens.

Stuartia pentagyna was named by Linnæus in compliment to John Stuart (Lord Bute), who was a prominent patron of botany in his time, and author of a remarkable book, of which some account has been recently given in the Journal of Botany.

Diospyros Virginiana.—The Date Plum, with large ripe fruit on the specimens, like ordinary plums in size and form.

Resemblance to our Nova Scotian flora is seen in the occurrence, in southern Kentucky, of *Rhododendron maximum*, the magnificent species brought from Ship Harbour, N. S., by the late Robert Morrow, many years ago (the history of which is given in our Transactions), and of such plants as *Vaccinium stamineum*, the widely spread *Viburnum acerifolium*, found by Cormack and De la Pylaie in Newfoundland, Richardson and Drummond from Lake Huron to the Saskatchewan, and Scouler and Douglas at Vancouver, and other species of which specimens were exhibited. Several of the ferns are identical with Nova Scotian species, such as *Lastrea Noveboracensis* and *Polypodium vulgare*, two of our common species, and the rarer *Asplenium Trichomanes*. There is also the Walking-leaf Fern, which, although generally regarded as a southern species, occurs in several parts of Ontario, as at High Falls, Portland Township, Oxford, Hamilton, Ancaster, Lake Medad, Wolfe Island, Owen Sound, and Ottawa,—having been also found at Montreal. Mr. Kearney's collection includes the beautiful and still more southern mountain spleen-wort, *Asplenium montanum*, of which fine, large tufts were shown.

III.—On the Calculation of the Conductivity of Aqueous Solutions containing the Double Sulphate of Copper and Potassium, and of Mixtures of Equimolecular Solutions of Zinc and Copper Sulphates. — By E. H. Archibald, B. Sc., *Dalhousie College, Halifax, N. S.*

(Communicated by Prof. J. G. MacGregor, 21st February, 1898.)

In a paper,* read before this Society last October, I showed that for mixtures of solutions of Potassium and Sodium Sulphate, when not more concentrated than one equivalent gramme-molecule per litre, it was possible, by the aid of the dissociation theory of electrolysis, and by employing Prof. MacGregor's graphical method† for the determination of the ionization coefficients in the mixture, to calculate the conductivity within or but little beyond the limits of an error of obsesvation. The conductivity of mixtures of solutions of Potassium and Sodium Chloride, which were measured by Bender, have been calculated by Prof. MacGregor,† who found that for mixtures of these solutions, more dilute than two equivalent gramme-molecules per litre, it was possible to caclulate their conductivity within the limits of experimental error. D. McIntosh ‡ has measured and calculated the conductivity of mixtures of solutions of Potassium and Hydrogen Chloride, and found the conductivity calculable within the limits of experimental error, up to a mean concentration of one equivalent gramme-molecule per litre.

At Prof. MacGregor's suggestion I have made the observations described in this paper, to find if the conductivity is also calculable in the case of a solution containing a double salt, on the assumption that the salt does not exist as a double salt in the solution. The salt selected was the double Sulphate of Copper and Potassium.

* Transactions N. S. Inst. Science, IX. (1897), p. 291.
† Transactions N. S. Iust. Sciencc, IX. (1896), p. 101.
‡ Transactions N. S. Inst. Science. IX. (1896), p. 122.

The work included the purification of the salts and of water, preparation and analysis of a series of simple solutions of the constituents of the double salt and determination of their conductivity; plotting curves, giving the relation of concentration of ions to dilution for these simple solutions; preparation of the double salt and of its solutions, and measuring and calculating their conductivity. The experiments were conducted in the Physical and Chemical Laboratories of Dalhousie College.

Purification of Materials.

The salts were obtained as chemically pure, from Eimer and Amend of New York. They were carefully re-crystallized three times. No iron or other impurities could be detected in the Cŏpper Sulphate.

The water used was purified by the method described by Hulett,* except that a block tin condenser was used instead of a platinum one. It was found to have at 18°C a conductivity varying from 0.88×10^{-10} to 0.97×10^{-10} expressed in terms of the conductivity of mercury at 0°C. It was kept in bottles which had been used for this purpose for several years. In the case of the more dilute solutions, where the water would appreciably effect the conductivity of the solution, the conductivity of the water used in making up a solution was substracted from the observed conducticity of that solution.

Experimental Methods.

Details as to the preparation and analysis of simple solutions and the measurement of the conductivity, will be found in the paper referred to above. I mention here only points in which the procedure of the present paper differs from the procedure of the former.

The only change in the apparatus was the use of a cylindrical electrolytic cell in measuring the more dilute solutions. This cell was about 14 cms. long, and had an internal diameter of 3.3 cms. It was provided with circular electrodes of stout platinum

* Journ. Phys. Chem., Vol. I., p. 91.

foil, not easily bent. The stems of these electrodes were fused into small glass tubes, which passed through, and were sealed to the ebonite cover of the cell. The electrodes were kept firmly in position by means of a rubber band, passing over the cover and around the bottom of the cell. This cell, being long, and of the same diameter throughout, could, by varying the distance between the electrodes, be used for solutions extending through a wide range of dilution.

In preparing the double Sulphate of Copper and Potassium, solutions of each salt were prepared of equal molecular concentration. In the case of the Potassium Sulphate these solutions were prepared by adding a known weight of anhydrous salt (which had been dried to constant weight in an air bath) to water so as to form a solution of known volume. For the Copper Sulphate a solution was made up, analysed by determining the sulphur present, and the required concentration obtained by adding a known volume of water to a known volume of solution. Equal volumes of these solutions were then mixed, and the mixture evaporated at a temperature below 70°C. If the temperature was allowed to rise above this point, a light green substance was precipitated out, which, according to Brunner,* is a basic double salt of Copper and Potassium.

When a sufficient quantity of the double salt had been prepared, portions were weighed out and analysed for the purpose of ascertaining the composition of the crystals. The method adopted was the determination of the copper present by precipitating it in the metallic state by means of pure zinc and hydrochloric acid in a platinum crucible. The results of three determinations agreed to within 0.11 per cent and indicated crystals of the composition $CuK_2(SO_4)_2 + 6\,H_2O$.

A solution of the double salt was then prepared and the concentration estimated by determination both of the copper and of the sulphur present in a definite volume of the solution, the results from the two methods agreeing to within 0.12 per cent.

* Pogg. Ann., 50, 43.

More dilute solutions were prepared from this one by adding water, and their concentrations calculated. Check analyses, however, were made after any portion had gone through a number of dilutions, and, if found necessary, the calculated concentrations were corrected from these results.

As the method of calculation required a knowledge of any appreciable change of volume which would occur on mixing simple solutions of each of the salts. of such strength as to form a solution of the same concentration as the solution of the double salt under investigation, density determinations were made of a number of such solutions, before and after mixing. These measurements were carried out with Ostwald's form of Sprengel's Pyknometer. They might be in error by about 5 in the fifth decimal place. No change of volume was found to occur on mixing the most concentrated solutions examined which would appreciably effect the calculation of the conductivity. The density of a mixture of the constituent solutions of the double sulphate was found in the case of some of the stronger solutions (the only ones tested) to be the same, within the limits of experimental error, as the density of a solution of the double salts of the same concentration.

For the simple solutions the ionization coefficient was taken to be equal to the ratio of the specific molecular conductivity to the specific molecular conductivity at infinite dilution. The values of the molecular conductivity at infinite dilution used in the calculations were:—1280×10^{-8}, and 1100×10^{-8} for Potassium and Copper Sulphate respectively, as determined by Kohlrausch.* I was not aware, at the time the calculations were made, that he had given 1270×10^{-8}, and 1120×10^{-8}, as better values for these salts.† I have, however, repeated some of the calculations and find that the difference caused by using these later values are in all cases less than 0.06 per cent.

* Wied. Ann., Vol. 26. p. 204.

† Wied. Ann., Vol. 50 (1893), p. 406.

Observations on Simple Solutions of Potassium and Copper Sulphates.

TABLE I.

Potassium Sulphate.			Copper Sulphate.		
Dilution.	Conductivity.	Concentration of ions.	Dilution.	Conductivity.	Concentration of ions.
400.0	1173	.002291	400.0	852	.001935
333.3	1166	.002732	333.3	832	.002266
285.7	1158	.003166	285.7	812	.002583
250.0	1152	.003600	250.0	795	.002890
222.2	1146	.004029	222.2	778	.003182
200.0	1140	.004453	200.0	763	.003465
181.8	1134	.00487	181.8	749	.00375
166.6	1130	.00530	166.6	738	.00403
150.0	1124	.00585	150.0	726	.00440
133.3	1116	.00654	133.3	713	.00486
125.0	1112	.00695	125.0	704	.00512
110.1	1104	.00783	110.1	687	.00567
100.0	1097	.00857	100 0	676	.00614
80.0	1083	.01057	80.0	651	.00737
60.00	1062	.01382	60.00	616	.00933
50.00	1046	.01634	50.00	592.0	.01076
45.00	1037	.01800	45.00	579.0	.01169
35.71	1015	.02220	35.71	545.5	.01388
30.00	997	.02596	30.00	522.5	.01583
25.00	978	.03054	25.00	497.0	.01807
20.00	960	.03748	20.00	479.6	.02180
16.66	945	.04432	16.66	465.8	.02541
15.00	936	.0487	15.00	457.5	.02773
13.33	925	.0542	13.33	447.0	.0305
12.50	918	.0574	12.50	441.8	.0321
11.01	905	.0642	11.01	431.7	.0356
10.00	895	.0699	10.00	423.5	.0385
8.00	872	.0852	8.00	403.2	.0458
6.000	840	.1093	6.000	378.1	.0573
5.000	824	.1287	5.000	359.5	.0654
4.500	815	.1414	4.500	349.9	.0707
3.571	792	.1731	3.571	329.0	.0837
3.000	775	.2018	3.000	318.0	.0963
2.500	756	.2363	2.500	304.5	.1110
2.000	736	.2877	2.000	288.2	.1310
1.500	709	.370	1.500	268.3	.1626
1.333	698	.409	1.333	261.3	.1781
1.101	679	.482	1.101	249.8	.2061
1.000	672	.525	1.000	242.1	.2200
.806	650	.630	.651	209.8	.292
.773	647	.654	.521	192.0	.335

The foregoing table, I, contains the necessary data for the drawing of the ionic concentration-dilution curves for each salt. Dilutions are expressed in terms of litres per equivalent gramme-molecule of anhydrous salt at 18°C. The conductivities are specific molecular conductivities (*i. e.* per gramme-equivalent) at 18°C, expressed in terms of 10^{-8} times the specific conductivity of mercury at 0°C. The concentrations of ions are the ratios of the specific molecular conductivity, to specific molecular conductivity at infinite dilution, divided by the dilution.

Observations on the Double Sulphate Solutions.

Table II contains both the data for, and the results of, the calculation of the conductivity of each solution of the double sulphate examined, together with the observed values, and the differences between observed and calculated values, expressed as percentages. The concentrations of solutions are expressed in terms of equivalent gramme-molecules of anhydrous salt per litre at 18°C. The conductivities are specific conductivities at 18°C, expressed in terms of 10^{-8} times the specific conductivity of mercury at 0°C. The concentration of ions common to the two electrolytes in a solution, and the dilutions of the electrolytes in the solution, are obtained by Prof. MacGregor's graphical method, on the assumption that a solution of double salt may be made by mixing equal volumes of equi-molecular solutions of the simple salts, and that, on mixing, the double salt does not form The former is the number of dissociated gramme-equivalents of either electrolyte, which on that assumption would be present in the solution, divided by the volume in litres of the portion of the solution occupied by it. In any one solution it will have the same value for both electrolytes. The latter are the volumes in litres of the portions of the solution occupied by the respective electrolytes, divided by the number of gramme-equivalents present. In each solution they will have different values for the two electrolytes. The product of the former into the value of the latter, in the case of either electrolyte gives the ionization coefficient for that electrolyte in the solution.

TABLE II.

Concentration of the Double Salt Solutions. ½ Cu $K_2(SO_4)_2$.	Concentration of ions in the Solution.	Dilution in the Solution. ½ K_2SO_4.	½ Cu SO_4.	Conductivity of Double Salt Solutions. Calculated.	Observed.	Differences per cent.
1.294	.4300	1.260	.284	535.9	504.1	+6.38
1.000	.3610	1.540	.460	447.0	423.5	+5.54
.909	.3350	1.682	.520	414.8	394.4	+5.17
.7500	.2875	2.000	.605	354.7	340.1	+4.29
.6666	.2615	2.226	.774	322.4	310.5	+3.83
.5000	.2072	2.910	1.090	254.9	246.3	+3.49
.4000	.1728	3.62	1.385	212.3	205.9	+3.11
.3333	.1480	4.29	1.710	181.7	176.7	+2.83
.2222	.1046	6.30	2.705	128.1	126.1	+1.59
.1666	.0816	8.32	3.68	99.85	99.21	+0.65
.1000	.0536	13.48	6.52	65.44	65.20	+0.37
.0909	.0494	14.76	7.26	60.34	60.21	+0.22
.0750	.0420	17.71	8.95	51.12	50.96	+0.31
.06666	.0379	19.80	10.21	46.13	46.26	−0.20
.05000	.0294	26.05	13.95	35.79	35.89	−0.28
.04000	.0242	32.3	17.66	29.43	29.40	+0.10
.03333	.0207	38.8	21.25	25.11	25.18	−0.28
.02222	.01455	56.5	33.5	17.64	17.59	+0.34
.01666	.01145	73.8	46.2	13.85	13.88	−0.22
.01000	.00729	119.0	81.0	8.784	8.760	+0.27
.00800	.00597	146.8	103.2	7.196	7.180	+0.22
.00750	.00565	156.0	110.5	6.797	6.776	+0.31
.00600	.00463	191.8	141.4	5.569	5.584	−0.26
.00500	.00393	228.4	171.6	4.719	4.730	−0.23

It appears from the above table that while in the case of solutions with concentration ranging from the weakest examined up to about 0.1 gramme-equivalent per litre, calculated and observed values agree within the limit of observational error, (which, as in the former paper, was estimated at 0.25 per cent), the differences between observed and calculated values for solu-

tions with concentration ranging from 0.1 to the highest examined. 1.294, are beyond the limit of error, and are much greater than the differences observed for mixtures of Potassium and Sodium Sulphate, or for any mixtures yet examined of a corresponding concentration. This result would appear therefore to support the view that the double salt does exist as such to a certain extent at any rate in solution.

Comparison of the Conductivity of Solutions of the Double Salt with Equivalent Mixtures of Solutions of its Constituents.

TABLE III.

Concentration.	Conductivity of Mixture.	Conductivity of Double Salt.	Differences per cent.
1.000	425.7	423.5	+0.52
.909	396.3	394 4	+0.48
.7500	341.2	340.1	+0 32
.6666	311.6	310.5	+0.35
.5000	246.9	246.3	+0 24
.4000	206.4	205.9	+0.24
.3333	176.4	176.7	-0.17
.2222	126.0	126.1	-0.07
.1666	99.33	99.21	+0.12
.1000	65.31	65.20	+0.16
.0909	60.29	60.21	+0.13
.07500	51.02	50.96	+0.11
.06666	46.20	46.26	-0.08
.05000	35.86	35.89	-0.08
.04000	29.45	29.40	+0.17
.03333	25.14	25.18	-0.15
.02222	17.62	17.59	+0.17
.01666	13.86	13.88	-0.14
.01000	8.770	8.760	+0.11
.00750	6.781	6.776	+0.07
.00600	5.574	5.584	-0.17
.00500	4.724	4.730	-0.12

It was thought, therefore, that it would be interesting to see to what extent a mixture of equal volumes of equi-molecular solutions of the constituents of the double sulphate of Potassium and Copper corresponded to a solution of the double salt of the same concentration. For that purpose mixtures were prepared of the same concentration as the solutions of the double salt previously examined. Table III gives the concentrations common to the mixtures and the solutions of the double salt, the observed conductivity of each, and the differences between the two values expressed as percentages. Concentrations and conductivities are expressed in terms of the same units as in Table II.

The results given in Table III show that in the case of the weaker solutions the differences are within the limits of experimental error, but that in the case of the first four solutions the errors of observation would need to be of opposite sign for the two solutions in each case in order to account for the differences observed. In the stronger solutions, therefore, the conductivity of the mixture would appear to be greater than the conductivity of the equally concentrated solutions of the double salt. This might be due to the molecules of the double salt not having become broken up in solution, to the extent that they are in a mixture of solutions of its constituents. Similar results for Potassium Chrome Alum have been observed by Jones and Mackay.*

Observations on Solutions containing Zinc aud Copper Sulphates.

As the large differences between the calculated and observed values of the conductivity, in the case of the double sulphate solutions, were still unaccounted for, I thought it advisable to see how closely it was possible to predict the conductivity of mixtures of equi-molecular solutions of each of the constituents of the double salt with some other sulphate with which it does not form a double salt of the same nature as the Potassium

* Am. Chem. Jour., Vol. XIX,, No. 2, p. 83.

Copper salt. For this purpose Zinc Sulphate was selected to be associated with Copper Sulphate and Sodium Sulphate with Potassium Sulphate.

In Table IV are given the data for the drawing of the ionic concentration-dilution curve for Zinc Sulphate. Conductivities, dilutions and concentrations of ions are expressed in terms of

TABLE IV.

Zinc Sulphate.		
Dilution.	Conductivity.	Concentration of ions.
100.0	684	.00633
80.0	665	.00770
66.66	647	.00899
50.00	610	.01129
40.00	582	.01347
33.33	555	.01541
25.00	520	.01925
22.22	508	.02117
20.00	500	.02314
16.66	484.0	.0269
13.33	463.0	.0322
12.50	455.0	.0337
10.00	430.4	.0399
8.00	414.0	.0479
6.666	400.0	.0556
5.000	375.0	.0694
4.000	354.5	.0821
3.333	341.0	.0947
2.500	317.0	.1174
2.222	309.0	.1287
2.000	302.0	.1308
1.666	290.5	.1614
1.333	270.6	.1879
1.176	260.8	.2052
1.000	248.5	.2300

the same units as in Table I. In calculating the concentration of ions, the value of the molecular conductivity at infinite dilution was taken to be 1080, according to Kohlrausch's* determination.

Mixtures of equal volumes of equi-molecular solutions of Zinc and Copper Sulphates were then prepared, and their conductivity measured. In Table V are given the necessary data for the calculation of the conductivity of each mixture examined, together with the observed and calculated values and the differences expressed as percentages. The different values are expressed in terms of the same units as in Table II.

TABLE V.

Concentration of the Constituent Solutions.		Concentration of ions in the Mixture.	Dilution in the Mixture.		Conductivity of Mixture.		
½ $ZnSO_4$.	½ $CuSO_4$.		½ $ZnSO_4$.	½ $CuSO_4$.	Calculated.	Observed.	Differences per cent.
1.000	1.000	.2252	1.032	.968	245.1	245.4	−0.12
.850	.850	.2006	1.212	1.140	215.6	215.3	+0.13
.7500	.7500	.1832	1.382	1.284	199.4	199.7	−0.15
.6000	.6000	.1562	1.744	1.588	170.1	170.5	−0.23
.5000	.5000	.1354	2.080	1.920	147.5	147.3	+0.12
.4000	.4000	.1144	2.600	2.400	124.6	124.5	+0.08
.2000	.2000	.0674	5.22	4.79	73.30	73.20	+0.13
.1000	.1000	.0393	10.22	9.78	42.76	42.83	−0.16
.0850	.0850	.0346	12.10	11.42	37.68	37.63	+0.13
.0750	.0750	.0314	13.80	12.86	33.82	33.88	−0.17
.06000	.06000	.02618	17.26	16.06	28.50	28.55	−0.17
.05000	.05000	.02245	20.70	19.30	24.05	24.01	+0.16
.04000	.04000	.01866	26.1	24.0	20.32	20.36	−0.19
.02000	.02000	.01105	51.6	48.4	12.03	12.05	−0.15
.01250	.01250	.00753	82.1	77.9	7.837	7.830	+0.08

* Wied. Ann. Vol. XXVI (1885), p. 195.

These results show that in the case of solutions containing equi-molecular quantities of Zinc and Copper Sulphate up to 1 gramme-equivalent per litre, the calculated and observed values of the conductivity agree within the limits of observational error.

Observations on Solutions Containing Sodium and Potassium Sulphate.

Table VI contains the results of calculations and observations on some mixtures of equal volumes of equi-molecular solutions of Sodium and Potassium Sulphates, of the same range of concentration as those of the Copper-Potassium Sulphate solutions and Zinc-Copper mixtures examined. The data for the drawing of the ionic concentration-dilution curve for Potassium Sulphate

TABLE VI.

Concentration of the Constituent Solutions.		Concentration of ions in the Mixture.	Dilution in the Mixture.		Conductivity of Mixture.		
½ K_2SO_4.	½ Na_2SO_4.		½ K_2SO_4.	½ Na_2SO_4.	Calculated.	Observed.	Differences per cent.
1.000	1.000	.483	1.096	.904	570.0	568.5	+0.26
.909	.909	.448	1.202	.998	528.1	526.6	+0.29
.750	.750	.384	1.432	1.234	451.9	452.8	−0.19
.6666	.6666	.351	1.605	1.395	413.3	414.4	−0.26
.5000	.5000	.276	2.105	1.895	323.8	324.6	−0.24
.4000	.4000	.228	2.60	2.40	267.7	267.2	+0.19
.2000	.2000	.1254	5.14	4 86	147.1	147.3	−0.13
.1000	.1000	.0696	10.06	9.94	81.40	81.49	−0 11
.0800	.0800	.0571	12.56	12.44	66.82	66.70	+0.18
.0750	.0750	.0540	13.40	13.26	63 12	63.02	+0.15
.06C0	.0600	.0441	16.76	16.56	51.60	51.67	−0.13
.0500	.0500	.0372	20.16	19.84	43.48	43.51	−0.07

are given in Table I. Similar data for Sodium Sulphate are given in my previous paper.* As the above data, in the case of the Potassium Sulphate, are better than those given in my previous paper, I have thought it well to make new observations and calculations on these mixtures. Concentrations, dilutions, concentrations of ions, and conductivities, are expressed in terms of the same units as in Table II.

The results of this table show that the calculated and observed values of the conductivity of mixtures of equi-molecular solutions of Potassium and Sodium Sulphates agree within the limits of observational error, at least up to a concentration of 1 gramme-equivalent per litre. The observations of my former paper, in which the mixtures examined were not equi-molecular in concentration, gave a similar result.

Conclusions.

An examination of Tables II, V, and VI, will show, that in the case of the Potassium-Copper sulphate solutions, the differences between the observed and calculated values of the conductivity, are all of the same sign and positive from a concentration of 0.1 to one of 1.294 equivalent gramme-molecules per litre, that the differences increase with the concentration, reaching in the case of the strongest solution examined 6.38 per cent.

For the mixtures of Sodium and Potassium Sulphates and of Zinc and Copper Sulphates examined, the difference for a like concentration are not greater than 0.30 per cent. Now, errors are caused in the calculations by taking the ionization coefficients to be the ratios of the specific molecular conductivity at infinite dilution, which is rigorously true only for infinitely dilute solutions, and also by taking the value of the specific molecular conductivity at infinite dilution for an electrolyte in a mixture to be the same as the value found by observations on the simple solutions, which is strictly true only for infinitely

* Loc. cit.

dilute mixtures. But the fact that the differences are so large where a double salt may exist, would seem to furnish evidence for the assumption, that in the more concentrated solutions of the double Sulphate of Potassium and Copper, the molecules of the double salt are not all broken up, but exist to some extent as a double salt in the solution.

For solutions of the Copper-Potassium sulphate, more dilute than 0.1 equivalent gramme-molecules per litre, as for the Zinc-Copper and Sodium-Potassium sulphate mixtures, through as wide a range of dilution as here examined, the differences are within the limit of observational error and change sign frequently, which seems to show that they are due to accidental errors. It is thus possible to calculate the conductivity of these solutions and mixtures; and it would follow that, as far as the conductivity measurements can show, for the more dilute solutions of Copper-Potassium sulphate there is no double salt existing as such in the solutions.

IV.—On the Calculation of the Conductivity of Aqueous Solutions containing the Chlorides of Sodium and Barium. — By T. C. McKay, B. A., *Dalhousie College, Halifax, N. S.*

(Read 14th March 1898.)

The object of this research was to test the possibility of calculating the conductivity of mixtures of solutions of the chlorides of sodium and barium by means of the dissociation theory of electrolytic conduction. It was undertaken at the suggestion of Prof. J. G. MacGregor, and was conducted in the Physical and Chemical Laboratories of Dalhousie College.

The method of calculation is fully described in one of Prof. MacGregor's papers.* It may suffice here to state that by a graphical treatment of the dilutions and ionic concentrations of series of simple solutions of the two electrolytes, the magnitude of the dilution of each salt, in the portion or region of a mixture which it may be supposed to occupy, can be found, together with the common value of the concentration of ions of the electrolytes in their respective regions. These having been found, their products give the ionization coefficients in the mixture, and the conductivity of the mixture is then obtained from the expression of the dissociation theory for the conductivity, viz.:—

$$k=\frac{1}{p(v_1+v_2)}\left(a_1\, n_1\, v_1\, \mu\infty_1+a_2\, n_2\, v_2\mu\infty_2\right),$$

where the α's represent the ionization coefficients of the electrolytes in the mixture, the n's the concentrations of the constituent solutions (in gramme-equivalents per litre), the v's the volumes of the constituent solutions, the μ_∞'s the specific molecular conductivities (*i. e.*, per gramme-equivalent) at infinite dilution, of the electrolytes in the mixture, and p the ratio of the volume of the mixture to the sum of the volumes of the constituent solu-

* N. S. Inst. of Sci., Trasactions, Vol. IX, p. 101.

tions. The method of procedure in calculation will be more exactly described after the experimental determinations have been dealt with.

To obtain the experimental data required in the calculation, it is necessary to make up a long series of solutions of each salt and measure their conductivity. The volumes of the constituent solutions before mixing must be known, and in cases where there is an appreciable change of volume on mixing the densities of the single solutions and of the mixture must be found. These determinations will be taken up in order.

Purity of Salts.

Of the salts used the sodium chloride had been furnished by Merck, the barium chloride by Eimer & Amend of New York. The former was tested for metals of the alkali and alkaline earth groups, as well as for iron. No indication of these was found. The barium chloride was tested by heating in a Bunsen flame. No impurities were discovered in this way. A further indication that the salts were sufficiently pure for the purpose in view is given by the comparison of the conductivities with those of Kohlrausch, as shown farther on in the paper. All the salt, however, used in the experiments described here, was recrystallized once by the writer.

Purity of Water.

The water used in making up the solutions was obtained by adding potassium hydroxide, about 1 gramme to a litre, to ordinary distilled water, and redistilling by means of a copper boiler lined with tin, the distillate being collected in a block-tin worm. The conductivity of the water before the potassium hydroxide was added was about 1.87 in terms of the conductivity of mercury at $0°C \times 10^{-10}$. After distillation the conductivity ranged from 1.1 to 0.95, the latter being that of the water used for the very dilute solutions.

At an earlier stage of the experiments water was purified by methods derived from a paper by G. A. Hulett.* Instead of the

* Journal of Physical Chemistry, Vol. I, No. 2.

platinum tube which he used, however, for condensing the water vapor, a block-tin tube was used. Generally, too, only the second distillation described by him was carried out, ordinary distilled water of a conductivity of 1.87 being treated with $Ba(OH)_2$, 50 c.c. of a saturated solution to two litres. The water distilled in this last way had a conductivity of about 1.11.

Methods of Making up Solutions.

The general plan adopted in making up a series of solutions of any salt was to dilute strong solutions by means of pipettes and measuring-flasks. In measuring off volumes of strong solutions the pipettes were rarely of smaller volume than 50 c.c. The flasks were filled to the mark when the salt solution and water added had been well mixed and had attained a temperature at or near 18°C. The calibration of the flasks and pipettes will be described in a future paragraph. Analyses were made of two or three of the solutions thus formed, of intermediate concentrations, and from these the concentrations of the other solutions of any one series were determined.

To obtain solutions with smaller differences of concentration than could be conveniently got by the above method, a known quantity of one of the solutions of a series, generally a volume of 100 c.c., was placed in the dry conductivity cell and diluted by small additions of water down to the next solution in the series. 5 c.c. were generally added four or five times from a pipette. After each addition of water had been made, and the liquid well mixed, a conductivity measurement was made. An analysis of the final solution was also made if the solution was not very dilute. In that case it was assumed that the increase in the volume of the solution was equal to the volume of water added. With the stronger solutions made up in this way, the shrinkage in the combined volumes of solution and water as shown by the experimentally determined concentration of the final solution was apportioned equally among the intermediate dilutions. Judging from the course of the curves representing conductivity and concentration good results were attainable is this way up to

a concentration of 0.6 gramme-equivalent per litre. Above that concentration the solutions, which were to be used in obtaining data for the calculations, were made up outside the cell. Two sets of solutions made in the cell in which the concentrations of the final solutions were calculated by a comparison of their conductivity with the conductivity of other solutions of approximately the same, and of known, concentration, were used to give an idea of the course of the conductivity-concentration curves between 0.7 and 1 gramme-equivalents per litre, but in none of the mixtures calculated and tabulated at the end of the paper does the determination of the ionisation coefficients require the use of these portions of the curves.

To test the validity, within the limits of experimental error, of the assumption, that, in the case of dilute solutions, the volumes of the latter are increased by the volume of water added, I made use of Kohlrausch and Hallwachs' observations of the specific gravity of solutions of sodium chloride.* For solutions whose concentration is not greater than 0.2 gramme-molecule per litre, the specific gravity may be represented to 1 in the fifth place of decimals by the equation

$$s = 1 + .04244m - .003m^2,$$

where s represents the specific gravity at 18°C and m the concentration in gramme-molecules per litre. The following is a comparison of the values obtained by this equation with those obtained by Kohlrausch and Hallwachs:—

m.	s (by formula).	s (K. & H.)
.2	1.008368	1.008358
.1	1.004214	1.004202
.05	1.002115	1.002111

Writing then k for the first constant in the formula, and l for the second, W for the weight of water in grammes, w for the weight of salt when divided by a the value of the molecular

* Wied. Ann., 53 (1894) p. 14.

weight of the substance (in this case 58.5), and D for the density of water at 18°C, we obtain :—

$$\frac{W+a\,w}{D\,v}-1 = \frac{kw}{v} + l\frac{w^2}{v^2}.$$

Then differentiating with respect to v, since w is a constant,

$$\frac{d\,v}{d\,W} = \frac{1}{D(1-l\frac{w^2}{v^2})} = \frac{1}{D(1-l\,m^2)},$$

which becomes in the above particular case

$$\frac{1}{D(1+.003m^2)}.$$

Therefore when m is sufficiently small to make the quantity $l\,m^2$ neligible, the increase of the volume of the solution is equal to the volume of the water added, since in that case

$$\frac{1}{D}\;\frac{dv}{d\,W} = 1.$$

Calibration of Flasks, Pipettes and Burettes.

The flasks were calibrated by weighing them empty and again when filled with distilled water of known temperature up to the mark. The error in calibrating a 250 c.c. flask was determined by a large number of measurements to be possibly .03 per cent. No flasks of less volume than 200 c. c. were used in making up solutions.

With the pipettes, the weight of water of known temperature which they delivered was found. In doing this the point was always held against the receiving vessel, and the liquid which remained in the point after the delivery was removed by blowing sharply into it once. The amount of water delivered in this way was determinable to about .005 c. c.

The burettes used held 50 c. c. and were graduated to tenths of 1 c. c. To calibrate them accurately it was found necessary to determine the volume of the tube for every 2 c. c., and in some cases for smaller lengths. These determinations were checked a large number of times by weighing the volumes of water between very various points on the tube. Readings could be made to .01 c. c., and the calibrations were carried nearly, if

not quite to that accuracy. In using them for making analyses volumes of 30 c. c. or over were delivered.

Analyses.

The strength of NaCl solutions was found by volumetric determination of the chlorine according to Mohr's method. Many of them also, particularly the stronger ones, were made up by weighing dry NaCl, which had been kept in a desiccator, in calibrated flasks, and filling up with water.

The $BaCl_2$ solutions were analyzed by precipitating the barium with Na_2SO_4. The barium sulphate was collected on filters and its amount determined in the ordinary way. In many cases also the amount of chlorine in the filtrate was determined volumetrically.

The volumetric analyses were not so reliable as the gravimetric, the error of the former sometimes reaching five-tenths of one per cent, though generally in the direct analyses of the chlorine, one or two tenths.

Conductivity Measurements.

The conductivity of the solutions whose strength had been determined in these various ways was measured by Kohlrausch's telephone method. The bridge wire, made of German silver, was divided into thousandths, which again admitted of easy subdivision by the eye into tenths. Of a set of four platinum resistances in the instrument, viz., 1000 ohms, 100, 10, and 1, the first two only were used. These were certified by Queen & Co., of Philadelphia, to be correct to one-fiftieth of one per cent. A number of solutions were compared with both of these resistances, and the difference between the conductivities thus measured lay within the limits of error.

To contain the solutions during the measurement of conductivity, two cells of different type were used. One was in the shape of a U-tube, the middle part being about $\frac{3}{8}$ inch in diameter and 5 inches long, while the two arms had each a diameter of $1\frac{3}{4}$

inches. The electrodes were of stout platinum and supported by platinum wires passing through the ebonite covers of the cell. The diameter of the electrodes was 1¼ inches. The second cell was a cylindrical vessel of diameter 1¼ inches. The electrodes, whose diameter was nearly as great, were also of platinum. The platinum wires leading from them were fused into glass tubes, in the interior of which they made connection through mercury with the outside wires. The glass tubes were moveable through holes in the cover of the cell so that the distance between the electrodes could be adjusted. For any given adjustment the tubes were held in place with sealing-wax. The solutions, whose conductivity could be measured in this cell, ranged from the most dilute to, in the case of sodium chloride, about .02 gramme-equivalent per litre. The range of of NaCl solutions which could be measured in the first cell varied from 0.1 to 5 gramme-equivalent per litre. The electrodes of both cells had been platinized in a solution containing 1 grm. of platinum tetrachloride and .008 grm. of lead acetate to 30 grm. of water.

Measurements were made near the temperature 18°C, almost always within 0.3 degree of that temperature. The thermometer could be read to .01 degree, and was corrected by comparison with a standard thermometer tested at the Physikalisch-Technische Reichsanstalt, Berlin. The thermometer was kept in a separate tube in the bath; and it was found, on several occasions, by placing another thermometer in the cell itself, that the temperature of the liquid in the cell could be read off from the thermometer in the tube in almost all cases to less than 0.1 degree. Where the measurements were not made at exactly 18°, correction was made by means of the temperature coefficients given in Fitzpatrick's Table in the British Association Reports.*

The bridge wire was calibrated by Strouhal and Barus' method. The resistances for this purpose were made of German silver wires, whose ends were soldered to short pieces of thick

* Nottingham, 1893.

copper wire. In order to draw the correction curve more accurately, the wire was calibrated by this means in a number of different fractions. The possible error of a conductivity measurement, when the reading was made at the middle of the bridge wire, was shown by a number of determinations to be about one-tenth of one per cent. For solutions of $BaCl_2$ and NaCl measured in the cell first described, the reading would be made at this part of the wire if the concentration was about 0.3 gramme-equivalent. For 0.5 gramme-equivalent solutions, with the reading at or near .64 of the length of the bridge, two-tenths per cent, for normal solutions four-tenths. With the cell for dilute solutions, the possible error, wherever the reading might be made, was about six-tenths. Here other sources of error, such as change of capacity of the cell, were greater than the bridge error. In order to obtain a good minimum also a high clear note from the induction coil was necessary when a very dilute solution was in the cell, and this could not always be obtained.

The capacity of each cell was determined by a comparison of the conductivities of the solutions measured in it, with the values given for corresponding solutions by Kohlrausch. The numbers given below, under the headings NaCl and $BaCl_2$ are the ratios of the conductivities of solutions measured in the first cell, to the specific conductivities of corresponding solutions, as measured by Kohlrausch.

Concentration.	Ratio.	
	NaCl.	$\frac{1}{2}BaCl_2$.
5	.2134	....
3	.2119	....
1	.2135	.2148
0.5	.2126	.2131

The mean of these ratios is .2131. This was taken as the calibration constant, and by means of it the conductivities of solutions measured in the first cell were expressed in Kohlrausch's units. The capacity of the second cell was determined in the same manner. It will be seen that the solutions above, which show the closest agreement with Kohlrausch's values, are those which could be measured near the middle of the bridge, viz., those of concentrations 0.5 and 5 gramme-equivalents per litre.

Observations on Simple Solutions.

The following tables give the concentrations and the conductivities of the simple solutions of NaCl and $BaCl_2$, by means of which the curves that show the relation between the ionic concentration and dilution were drawn.* The concentrations are expressed in gramme-equivalents per litre for the temperature of 18°C. The conductivities are expressed in terms of the conductivity of mercury at 0°C, multiplied by 10^{-8}, the temperature being also 18°C.

* See paragraph on making up of solutions.

NaCl.		½ $BaCl_2$.	
Concentration.	Conductivity.	Concentration.	Conductivity.
5.013	2002	2.775	1390
3.010	1594	2.317	1245
2 005	1212	2.029	1139
1.994	1211	.6796	469.8
.9986	693.1	.6494	447.7
.7964	576.3	.6005	424.2
.5979	444.9	.5661	403.7
.5016	380.7	.5060	366.4
.4781	366.3	.4800	349.3
.4383	335.1	.4580	334.7
.4194	323.2	.4016	297.5
.4030	311.3	.3850	287.3
.3360	263.5	.3044	234.2
.2996	237.3	.2747	212.6
.2477	198.7	.2018	160.1
.2177	175.5	.1915	153.3
.2004	162.9	.01113	11.12
.1935	158.3	.00955	9.66
.1818	149.3	.00837	8.54
.01002	9.64	.00744	7.62
.00915	8.78	.00667	6.85
.00839	8.11	....	....
.00775	7.54	....	....
.00672	6.54	....	....

The conductivity of the water used in making up the above solutions did not need to be taken into account. The water used in making up the weakest NaCl solution had a conductivity equal to less than two-tenths of one per cent of the conductivity of the solution itself.

Density.

Recurring to the formula for the conductivity of a mixture of two electrolytes, given at the beginning of the paper, it will be seen that the ratio of the volume of the mixture to the sum of the volumes of the constituent solutions is required. When equal volumes are mixed as was the case in the present determinations, this ratio is equal to the ratio which the mean density of the constituent solutions has to the density of the mixture. The ratio is generally so nearly equal to 1 as to be negligible. Still its value was calculated for the mixtures of solutions above 0.2 gramme-equivalent per litre. The greatest difference from unity in the mixtures studied was .0017. The densities of the simple solutions were taken from Kohlrausch and Hallwachs' determinations in the case of NaCl, and from the British Association report before referred to in the case of $BaCl_2$. The densities of the mixtures were determined by the writer by means of Ostwald's form of Sprengel's pycnometer. The error might be about 1 in the fourth place of decimals.

Preparation of Mixtures.

The mixtures examined were in all cases mixtures of equal volumes. They were made either with the same pipette or with pipettes of equal volume. These were filled with the respective solutions at the temperature 18°C, and delivered into dry flasks or bottles.

Procedure in Calculation.

In making a calculation of the conductivity of any mixture, the conductivities and concentrations of the single solutions were first plotted on coordinate paper. From the curves thus obtained

the conductivities at regular intervals were read off and divided by the value of μ_∞ for that salt, Kohlrausch's values being employed, viz., for sodium chloride 1030 and for barium chloride 1150, the conductivity unit being the same as hitherto. The quotients thus obtained were taken to be the values of the ionic concentrations. These last, divided by the corresponding dilutions, were plotted against the dilutions, and from the curves thus obtained, by Prof. MacGregor's graphical process, the common value of the ionic concentration of the electrolytes in their respective regions in the mixture and their dilutions throughout these regions, were found. The products of the latter values and the former gave the corresponding ionization coefficients. The plotting was done on very various scales as was necessary in order to plot all the curves so that readings could be made to 0.1 per cent. The calculation of the conductivity required three readings from the curves representing ionic concentration and dilution. Supposing these curves correct, the error involved in making these readings might amount to 0.15 or 0.2 per cent.

Results of Calculations.

The following table gives the results of the calculation of the conductivity of the mixtures. The first two columns give the concentration in gramme-equivalents per litre of the NaCl and $BaCl_2$ solutions before mixing, their volumes being then equal. The third, fourth, and fifth columns give the ionic concentrations and the dilutions of each salt in its portion of the mixture, each of these being expressed in terms of the units and quantities before described. The sixth and seventh columns give the specific conductivity at 18°C, in terms of 10^{-8} times the specific conductivity of mercury as calculated, and the value of the same determined experimentally. The eighth column gives the excess of the calculated over the measured value expressed in fractions of 1 per cent of the latter.

Concentration.		Concentration of ions in the Mixture.	Dilution in Mixture.		Conductivity.		
NaCl.	½ $BaCl_2$.		NaCl.	½ $BaCl_2$.	Calculated.	Measured.	Difference per cent.
3.012	2.029	1.282	.4439	.3283	1373	1380	—.5
2.007	2.775	1.195	.4886	.3672	1304	1310	—.5
2.007	2.029	1.079	.5580	.4322	1167	1171	—.4
.9986	.3044	.4501	1.601	1.315	474.8	473	+.4
.7964	.3044	.3853	1.903	1.586	407.8	407.6	+.1
.5979	.6404	.4084	1.658	1.574	445.2	444.9	+.1
.4994	.4048	.3128	2.377	2.009	337.7	339.8	—.6
.4994	.3044	.2852	2.641	2.289	307.9	307.4	+.2
.4013	.4048	.2803	2.688	2.275	304.0	304.9	—.3
.4013	.3044	.2457	3.098	2.635	270.6	270.8	—.1
.00602	.01113	.00757	123.9	116.8	8.577	8.56	+.2
.01002	.00667	.00756	116.9	124.0	8.166	8.159	+.1
.01002	.01113	.00961	96.54	90.85	10.38	10.36	+.2
.00602	.00667	.00582	162.9	153.3	6.36	6.322	+.6

In the case of solutions of from 0.3 to 0.5 gramme-equivalent per litre, which can be measured in the first cell, under the most favorable circumstances, the combined error of conductivity and analysis may amount to about 0.3 per cent. In the case of normal solutions it may reach 0.6 per cent, and in the case of very dilute solutions 0.6 per cent also. Hence, except in the case of the first solution of the above table and one other, the differences of the last column are all within the limits of experimental error. Also, the number of positive differences is about the same as the number of negative, and except that in the three strongest solutions they are all negative, and in the

four weakest all positive, the differences exhibit the alternation of sign which we would expect if they were due to accidental errors.

The results of the experiments, therefore, lead the writer to conclude that it is possible, by means of the dissociation theory, to calculate the conductivity of mixtures of solutions of the chlorides of sodium and barium at least for solutions whose concentrations are not above 2 gramme-equivalents per litre.

V.—ON THE RELATION OF THE SURFACE TENSION AND SPECIFIC GRAVITY OF CERTAIN AQUEOUS SOLUTIONS TO THEIR STATE OF IONIZATION.—BY E. H. ARCHIBALD, B. SC., *Dalhousie College, Halifax, N. S.*

(Communicated by Prof. J. G. MacGregor, December 13th, 1897.)

In a paper communicated to this Society last winter, Prof. MacGregor* pointed out that according to the ionization conception of the constitution of a solution of an electrolyte, in the case of a solution in which the dissociation was not complete, the difference between the physical properties of the solution and those of its solvent, must be compounded of the differences produced by the undissociated molecules and by the free ions. He drew from this that it should be possible to express the numerical values of the various properties of such a solution in terms of the state of ionization of the electrolytes it contained. In sufficiently dilute simple solutions where the molecules dissociated or undissociated might be regarded as being far enough apart to render mutual action between them impossible, such an expression would be of the simple form,

$$S=S_w+k(1-a)n+l\,a\,n \quad\ldots\ldots(1),$$

where S is the numerical value of any property of a solution (density, surface tension, &c.,) S_w that of the same property of water under the same physical conditions, n the number of equivalent gramme-molecules per unit volume, a the ionization coefficient of the electrolyte in the solution, and l and k constants, called ionization constants, for any given property of any given electrolyte. In the case of mixtures of simple solutions, provided no change of volume occurs on mixing, the expression will be of the form,

$$S=S_w+\left(k_1(1-a_1)n_1+l_1a_1n_1\right)\frac{v_1}{v_1+v_2+\&c.}$$
$$+\left(k_2(1-a_2)n_2+l_2a_2n_2\right)\frac{v_2}{v_1+v_2+\&c.}+\&c. \quad\ldots\ldots(2),$$

* Tran. N. S. Inst. Sci., Vol. IX., p. 219.

where the n's are the numbers of equivalent gramme-molecules contained in unit volume of the original simple solutions, the α's are the ionization coefficients in the mixture of the respective electrolytes mixed, the v's the respective volumes of the original simple solutions mixed, and the l's and k's the ionization constants found for the simple solutions of the several electrolytes.

Prof. MacGregor applied the above expressions to the calculation of the density, thermal expansion, &c., of some simple solutions and mixtures of Potassium and Sodium Chlorides, and found it possible to calculate the various properties of these solutions within the limits of experimental error.

At his suggestion I have carried out the observations and calculations described in this paper, to see if it is possible to represent by the first of the above expressions the density and surface tension of simple solutions of Sodium, Potassium and Copper Sulphates, salts of more complex molecular structure than those previously examined, and then, by means of the ionization constants thus obtained, to predict the values of the same properties for mixtures of solutions of these salts. I have also thought it well to test the possibility of predicting the specific gravity of solutions containing Potassium Sulphate and Sodium Chloride, and consequently also Sodium Sulphate and Potassium Chloride.

Data for the Calculations.—Experimental Methods.

The methods employed in purifying the water and salts used, and of preparing and mixing solutions and determining their concentration and conductivity, were the same as described in the papers I have read before the Institute during the present session.*

Observations of Surface Tension.

I have made no observations of surface tension myself, but have used those made by Rother.† His measurements were made at 15°C, and are there therefore not strictly comparable with

* Tran. N S. Inst. Sci., Vol. IX., p. 291, and 307.
† Wied. Ann., 21 (1884), p. 576.

calculated values based on the values of ionization-coefficients for 18° C. I have, however, calculated some of the ionization-coefficients, for the different salts, corresponding to 15°C, by using the conductivity coefficients given by Kohlrausch, and find that the differences between the values for 18° and 15° are not large enough to cause any appreciable error in the calculations Rother seems to regard his measurements as possibly in error by 5 to 8 in the third decimal place. He found the surface. tension of the water he used to be 7.357.

Observations of Specific Gravity.

The specific gravity observations were all made at 18°C, and are referred to water at 18°C. Ostwald's form of Sprengel's pyknometer was used in making the measurements. It was filled by dipping one arm in the solution to be measured and connecting the other by means of a rubber tube with an exhaust bottle. When the pyknometer had filled beyond the constant volume mark on the stem, it was placed in a water bath provided with a mechanical stirrer, which was connected with a water wheel driven by the water from a tap. The temperature of the bath was not allowed to vary more than a twentieth of a degree from 18°. When the liquid column in the arm had remained stationary for three or four minutes the meniscus was adjusted to the mark, the pyknometer taken from the bath, dipped in distilled water, then carefully dried with a linen cloth and weighed. From several measurements of the same solution, it would appear that the values of the specific gravity might be in error by about 5 in the fifth decimal place.

The Ionization Coefficients.

For simple solutions, the ionization coefficients, as in former papers, were taken to be the ratios of the specific molecular conductivity to the specific molecular conductivity at infinite dilution. The data for finding them for the simple solutions of Potassium, Sodium, and Copper Sulphates will be found in the above papers. In the case of the chlorides of Potassium and

Sodium, the data are taken from my paper on the "Conductivity of Solutions containing Potassium Sulphate and Sodium Chloride."*

In calculating the ionization coefficients, the values of the specific molecular conductivity at infinite dilution which I used, were those first given by Kohlrausch,† viz., 1280×10^{-8}, 1060×10^{-8}, 1100×10^{-8}, 1220×10^{-8}, and 1030×10^{-8}, in terms of the conductivity of mercury at 0°C, for Potassium, Sodium, and Copper Sulphates, and Potassium, and Sodium Chlorides, respectively. Kohlrausch‡ has since published what he considers closer values for the sulphates, viz., 1270, 1070, 1120, for the Potassium, Sodium, and Copper Sulphates respectively. Having had my attention drawn to these later values. I have recalculated a few of the ionization constants, and find that the difference caused by using the later values is in all cases negligible.

The following table contains the values of the ionization coefficients used in the calculations. They apply to 18°C. Concentrations of solutions are expressed in terms of equivalent gramme-molecules of anhydrous salt, per litre, at 18°C.

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* Trans. Roy. Soc., Can., 2nd Ser., Vol. 3. Sec. 3.

† Wied. Ann., Vol. XXVI, p. 204.

‡ Wied. Ann., 50 (1893), p. 406.

TABLE I.

Concentration.	Ionization Coefficients at 18°C.				
	½ K_2SO_4.	½ Na_2SO_4.	½ $CuSO_4$.	K Cl.	NaCl.
.8416	....	.473	....	....	....
.7500	.545	....	.238	....	....
.7100	....	.492	....	....	....
.6666	.554	....	.244	....	....
.6000	....	....	....	.780	.718
.5050	....	.527	....	....	....
.5000	.576	....	.262	.786	.737
.4000	.591	....	.278	.794	.757
.3366	....	.565	....	....	....
.3333	.606	....	.289	....	....
.2525	....	.591	....	....	....
.2500	....	....	....	.811	.786
.2222	.636	....	.318	....	....
.2000	....	....	....	.829	.805
.1442	....	.625	....	....	....
.1000	.697	....	.385	.854	.841
.0918	....	.698	....	....	....
.0800	....	....	....	.860	.853
.0750	.721	....	.406	.863	.857
.0666	.727	....	.416	....	....
.0631	....	.730	....	....	....
.0600	....	....	....	.873	.866
.05000	.749	....	.436	.882	.871
.04809	....	.744	....	....	....
.03258	....	.775	....	....	....

The ionization coefficients of the salts in the mixture were determined by Professor MacGregor's* graphical method. The above table contains all the data required for finding them, as specific gravity measurements showed that even for the strongest solutions the change of volume on mixing was negligible.

Determination of Ionization Constants.

In determining the ionization constants (k and l in expression (1)) for any salt, and for either property, the data for the six weakest solutions examined were in all cases employed; and the values of the constants were found from these data by the method of least squares.

The values thus found were employed in calculating the values of the properties of the various mixtures.

Results of the Caculations.—Simple Solutions.

The following table contains the values of the ionization constants for the various salts and for the two properties investigated, with the values of the properties calculated by means of these constants, and the differences between observed and calulated values. Concentrations of solutions are expressed in terms of the same units as in Table I.

TABLE II.—SURFACE TENSION AT 15°C, *(Rother's Observations)*.

Concentration.	Observed Value.	Calculated Value.	Differences.	Concentration.	Observed Value.	Calculated Value.	Differences.
$\frac{1}{2}K_2SO_4$.—(k=0.09627 ; l=0.18001).				$\frac{1}{2}Na_2SO_4$.—(k=0.11146 ; l=0.14223).			
.2341	7.392	7.392	0.000	.2041	7.393	7.394	+0.001
.3881	7.414	7.413	− 1	.4796	7.418	7.418	0
.3946	7.415	7.414	− 1	.7404	7.450	7.450	0
.3966	7.415	7.415	0	1.008	7.481	7.482	+ 1
.3976	7.415	7.415	0	.4773	7.418	7.418	0
.6038	7.442	7.443	+ 1	.4827	7.421	7.418	− 3
.8131	7.473	7.472	− 1	.9995	7.471	7.481	+ 10
1.244	7.537	7.543	+ 6	1.557	7.541	7.552	+ 11

* Trans. N. S. Inst. Science, IX (1896), p. 101.

TABLE III.—SPECIFIC GRAVITY *(at 18°C, referred to water at 18°C).*

Concentration.	Observed Value.	Calculated Value.	Differences.	Concentration.	Observed Value.	Calculated Value.	Differences.
½ K_2SO_4.—(k=0.05831; l=0.07728).				½ Na_2SO_4.—(k=0.05429; l=0.07207).			
.0500	1.00360	1.00363	$+0.0_4 3$	.01980	1.00135	1.00136	$+0.0_4 1$
.0666	1.00481	1.00480	− 1	.03258	1.00225	1.00222	− 3
.0750	1.00535	1.00539	+ 4	.04809	1.00328	1.00325	− 3
.1000	1.00718	1.00715	− 3	.06312	1.00423	1.00425	+ 2
.2222	1.01566	1.01564	− 2	.09181	1.00609	1.00612	+ 3
.3333	1.02323	1.02326	+ 3	.1442	1.00947	1.00943	− 4
.4000	1.02782	1.02781	− 1	.2525	1.01635	1.01636	+ 1
.5000	1.03457	1.03460	+ 3	.3366	1.02163	1.02165	+ 2
.6666	1.04572	1.04584	$+0.0_3 1$	.5050	1.03213	1.03214	+ 1
.7500	1.05130	1.05149	$+0.0_3 2$	.8416	1.05263	1.05276	$+0.0_3 1$
½ $CuSO_4$.—(k=0.07109; l=0.1072).				½ $CuSO_4$.—*(Continued.)*			
.0500	1.00433	1.00434	$+0.0_4 1$	.2222	1.01829	1.01833	$+0.0_4 4$
.0666	1.00576	1.00574	− 2	.3333	1.02722	1.02718	− 4
.0750	1.00640	1.00643	+ 3	.4000	1.03240	1.03245	+ 5
.1000	1.00855	1.00851	− 4	.5000	1 04016	1.04029	$+0.0_3 1$
KCl.—(k=0.06676; l=0.04556).				$NaCl$.—(k=0.03109; l=0.04445).			
.0500	1.00245	1 00241	$-0.0_4 4$	.0500	1.00211	1.00213	$+0.0_4 2$
.0600	1.00289	1.00290	+ 1	.0600	1.00254	1.00256	+ 2
.0750	1.00368	1.00364	− 4	.0750	1.00320	1.00319	− 1
.0800	1.00390	1.00388	− 2	.0800	1.00344	1.00340	− 4
.1000	1.00482	1.00486	+ 4	.1000	1.00420	1.00421	+ 1
.2000	1.00956	1.00958	+ 2	.2000	1.00836	1.00837	+ 1
.2500	1.01233	1.01231	− 2	.2500	1.01041	1.01039	− 2
.4000	1.01970	1.01985	$+0.0_3 2$	.4000	1.01645	1.01648	+ 3
.5000	1.02401	1.02512	$+0.0_2 1$	.5000	1.02041	1.02047	+ 6
.6000	1.02860	1.03013	$+0.0_2 2$	.6000	1.02420	1.02440	$+0.0_3 2$

Comments on above Tables.

Surface Tension.—The differences between observed and calculated values are well within the limits of error, through the whole range of the observations used in determining the ionization constants; and in the case of the K_2SO_4 somewhat beyond this. The alternation of sign is also satisfactory.

Specific Gravity.—For all the salts examined, and through a somewhat greater range of concentration than that of the observations used in determining the constants, the differences are within the limits of error. Change of sign is also quite satisfactory.

It thus appears that for both properties of all the salts examined, the expression under consideration represents the observed values well throughout the range to which it has been applied.

Mixtures.

Tables IV and V contain the results of the endeavor to predict the values of the surface tension and specific gravity for mixtures by means of the above expression (2) of page 335, employing the values of the ionization constants obtained as above from observations on simple solutions. All the mixtures whose specific gravity I determined, were mixtures of equal volumes of the constituent solutions. Rother's mixtures were mixtures of equal weights, which renders the calculations much more tedious. His paper, however, furnishes the requisite data for determining the volumes of the solutions which he mixed; and these are given in the table below. As I had equi-molecular solutions of the Copper and Potassium Sulphates prepared for the purpose of finding their electrical conductivity, these solutions were used in preparing the mixtures for specific gravity measurements.

The following tables also contain the ionization coefficients in the mixtures, as determined by the graphical method referred to above. Concentrations of solutions are expressed in terms of equivalent gramme-molecules of anhydrous salt per litre at 18°C. The specific gravities are those at 18°C, referred to water at 18°C.

TABLE IV.—SURFACE TENSION (*Rother's Observations*).

Constituent Solutions. Concentration. $\frac{1}{2}K_2SO_4$.	Constituent Solutions. Concentration. $\frac{1}{2}Na_2SO_4$	Constituent Solutions. Volumes (litres). $\frac{1}{2}K_2SO_4$.	Constituent Solutions. Volumes (litres). $\frac{1}{2}Na_2SO_4$	Ionization Coefficients in the Mixture. $\frac{1}{2}K_2SO_4$.	Ionization Coefficients in the Mixture. $\frac{1}{2}Na_2SO_4$	Observed Value.	Calculated Value.	Difference.
.2341	.2041	.14770	.14738	.631	.587	7.394	7.393	-0.0_21
.3881	.4796	.14622	.14575	.588	.540	7.416	7.413	− 3
.3946	.7404	.14616	.14355	.573	.509	7.433	7.432	− 1
.3966	1.008	.14614	.14143	.560	.487	7.451	7.455	+ 4
.3976	.4773	.14613	.14577	.587	.538	7.420	7.417	− 3
.6038	.4827	.14422	.14572	.574	.512	7.432	7.432	0
.8131	.9995	.14229	.14151	.540	.450	7.470	7.476	+ 6
1.244	1.557	.13878	.13742	.508	.389	7.539	7.549	+ 0.01

TABLE V.—SPECIFIC GRAVITY.

Sodium and Potassium Sulphate Mixtures.

Concentrations of Constituent Solutions. $\frac{1}{2}K_2SO_4$.	Concentrations of Constituent Solutions. $\frac{1}{2}Na_2SO_4$.	Ionization Coefficients in Mixture. $\frac{1}{2}K_2SO_4$.	Ionization Coefficients in Mixture. $\frac{1}{2}Na_2SO_4$.	Specific Gravity of Mixture. Observed Value.	Specific Gravity of Mixture. Calculated Value.	Specific Gravity of Mixture. Difference.
.02500	.0505	.771	.750	1.00256	1.00261	$+0.0_45$
.0500	.0505	.748	.737	1.00354	1.00351	− 3
.1000	.0673	.718	.709	1.00577	1.00582	+ 5
.1000	.1010	.701	.691	1.00690	1.00693	+ 3
.2500	.2525	.636	.593	1.01694	1.01698	+ 4
.2500	.5050	.598	.551	1.02484	1.02489	+ 5
.3333	.5050	.592	.544	1.02777	1.02774	− 3
.4166	.5050	.586	.534	1.03060	1.03056	− 4
.4957	.4996	.578	.523	1.03300	1.03305	+ 5
.5000	.5050	.577	.522	1.03331	1.03337	+ 6
.4957	.6658	.570	.507	1.03809	1.03820	$+0.0_31$

TABLE V. *(Continued)*—SPECIFIC GRAVITY.

Copper and Potassium Sulphate Mixtures.

Concentrations of Constituent Solutions.		Ionization Coefficients in Mixture.		Specific Gravity of Mixture.		
½ K_2SO_4.	½ $CuSO_4$.	½ K_2SO_4.	½ $CuSO_4$.	Observed Value.	Calculated Value.	Difference.
.04000	.04000	.783	.427	1.00322	1.00319	− 0.0_43
.05000	.05000	.766	.410	1.00395	1.00397	+ 2
.06666	.06666	.749	.386	1.00527	1.00525	− 2
.07500	.07500	.743	.376	1.00591	1.00589	− 2
.0909	.0909	.729	.359	1.00707	1.00710	+ 3
.1000	.1000	.722	.349	1.00783	1.00780	− 3
.1666	.1666	.679	.300	1.01271	1.01275	+ 4
.2222	.2222	.658	.283	1.01694	1.01690	− 4
.3333	.3333	.635	.253	1.02503	1.02510	+ 7
.4000	.4000	.625	.239	1.03000	1.03006	+ 6
.5000	.5000	.603	.226	1.03720	1.03734	+ 0.0_31

It appears from the above Tables IV and V that the differences between calculated and observed values are within the limits of error, throughout nearly the same range of concentration as that of the observations on simple solutions used in determining the constants. This range is somewhat greater for the Sodium and Potassium Sulphate mixtures than for the Copper and Potassium Sulphate mixtures, which would seem to support the view taken of these mixtures in my previous paper, viz., as to the existence of a double salt in the solution. It might also be mentioned here, in support of this view, that for mixtures of stronger solutions of the Copper and Potassium Sulphates than are here given, I have observed a quite noticeable change of volume on mixing which is not the case for mixtures of solutions of the Sodium and Potassium Sulphates for a like concentration.

As the ionization constants used in the calculations were not determined from the observations of these tables, such alternation

of sign is not to be expected in the differences as was observed in the differences between observed and calculated values for the simple solutions. In any case in which variation of sign might be expected, as in the case of mixtures of the Copper and Potassium Sulphates where the solutions mixed were equimolecular, alternation of sign in the differences is quite satisfactory.

The results of the above tables would seem to warrant the conclusion that it is posssible by aid of the dissociation theory of electrolysis, to predict the surface tension and specific gravity of mixtures of moderately dilute solutions of Sodium Sulphate with Potassium Sulphate and Potassium Sulphate with Copper Sulphate within the limits of the error of observation, by means of data obtained by observations on simple solutions of these salts.

Observations on the Specific Gravity of Solutions containing Potassium Sulphate and Sodium Chloride.

As it appears from the above results to be possible to predict the specific gravity of a mixture of two solutions of sulphates, and from Prof. MacGregor's results in the case of mixtures of two chlorides also, I thought it would be interesting to see if a similar prediction was possible in the case of a mixture of a sulphate solution with that of a chloride of a different metal In such a case there will be four electrolytes present in the solution. Hence the formula for calculating, expression (2) on page 335, will involve four each of the quantities k, l, a, n, v, and the calculation is thus extremely difficult. Prof. MacGregor has found it practically impossible to calculate even the conductivity in the case of mixtures of any two solutions taken at haphazard. I therefore did not attempt to do so in the case of the specific gravity. The plan adopted was that of my paper on the conductivity of solutions containing Potassium Sulphate and Sodium Chloride,* viz., to prepare simple solutions of the four salts having the same concentration of ions and to mix

* *Loc. cit.*

these in the proportions as to volume requisite to prevent change of ionization on mixing, and then to measure and calculate the specific gravity of the mixture. For the exact mode of determining the ionization coefficients, concentrations and volumes of the four simple solutions to be mixed, I may refer to my paper cited above. All the data required for the calculations are given in Table VI, together with the calculated and observed values. The concentrations of solutions and specific gravities are expressed in terms of the same units as in previous tables. The column headed "volumes" contains the volumes in c. c. of the Potassium and Sodium Chloride solutions mixed with 25 c. c. each of the sulphate solutions.

TABLE VI.

Constituent Solutions.						Specific Gravity $\frac{18^\circ}{18^\circ}$		
Concentration.				Volumes in c. c. of K Cl and Na Cl. Solutions.	Concentration of ions.	Observ'd.	Calculated.	Difference.
K Cl.	NaCl.	$\frac{1}{2}K_2SO_4$.	$\frac{1}{2}Na_2SO_4$					
.0500	.0512	.0607	.0611	30 53	.0445	1.00325	1.00319	-0.0_46
.0527	.0536	.0610	.0614	30.57	.0467	1.00339	1.00334	— 5
.0648	.0659	.0791	.0800	30.88	.0568	1.00403	1.00410	+ 7
.0787	.0800	.0969	.0984	31.25	.0683	1.00492	1.00500	+ 8
.1032	.1063	.1287	.1419	34.37	.0887	1.00664	1.00668	+ 4
.1219	.1265	.1552	.1700	34.85	.103	1.00795	1.00789	— 6
.1310	.1349	.1674	.1834	34.99	.112	1.00849	1.00847	— 2
.1675	.1736	.2201	.2374	35.42	.141	1.01084	1.01092	+ 8
.2008	.2083	.2702	.2902	36.14	.167	1.01310	1.01317	+ 7
.2380	.2500	.3225	.3478	36.56	.196	1.01556	1.01568	$+0.0_31$

The above table shows that in all except the last solution examined the differences between the observed and calculated values are either within or but little beyond (in three cases within and in six a little beyond) what I consider my possible error of observation. They are also about equally divided as to sign. Considering the large number of sources of error involved

in the preparation of the solutions, and in the calculations, the agreement between observed and calculated values seems to me to be exceedingly satisfactory, and to justify the conclusion that even in this very complex case it is possible by aid of the dissociation theory to predict the specific gravity within the limits of experimental error.

Summary of Conclusions.

(1.) Expression (1) represents observed values of the surface tension and specific gravity of the solutions examined through a range of concentration extending from 0.05 to about 0.4 or 0.5 equivalent gramme-molecules per litre.

(2.) It is possible by aid of the dissociation theory of electrolysis to predict the surface tension and specific gravity of mixtures of Potassium and Sodium Sulphate solutions and the specific gravity of mixtures of solutions of Potassium and Copper sulphates throughout nearly the same range as above, within the limits of the error of observation.

(3.) It is possible by aid of the above theory to predict the specific gravity of mixtures of solutions of Potassium Sulphate and Sodium Chloride within the limits of experimental error.

VI.—On the Calculation of the Conductivity of Aqueous Solutions of Potassium-Magnesium Sulphate.—By T. C. McKay, B. A., *Dalhousie College, Halifax, N. S.*

(Read March 9th, 1898.)

The measurements and calculations, the results of which are given in this paper, were made with a view to finding out whether the conductivity of solutions of the double sulphate of potassium and magnesium could be calculated on the supposition that it separates on solution in water into potassium sulphate and magnesium sulphate. The research was undertaken at the suggestion of Professor MacGregor, and carried out in the physical and chemical laboratories of Dalhousie University.

The method by which the calculation of the conductivities was made is based on the dissociation theory of electrolysis, and was devised by Professor MacGregor for the calculation of conductivities of mixtures of two electrolytes containing a common ion.* The writer showed in a former paper† that by the use of this method of calculation, the conductivity of mixtures of solutions in water of the chlorides of sodium and barium could be calculated on the supposition that the two salts exist separately in the solution. Most of the experimental methods used in the present research were described in that paper, and need not be referred to here.

The potassium sulphate used in the determinations was obtained from Eimer & Amend, New York; the magnesium sulphate, partly from Eimer & Amend and partly from Merck. All the salt obtained from the former was recrystallized once. Merck's magnesium sulphate was his guaranteed reagent, and with the exception of that used for some $MgSO_4$ solutions from .5 to 1 gramme-equivalent per litre, was not recrystallized by the writer. The salts were tested with silver nitrate for the

*Trans. N. S. Inst. Sc., Vol. IX., p. 101.
†Trans. N. S. Inst. Sc., Vol. IX., p. 321.

presence of chlorides, and with potassium ferrocyanide for iron. In none of these tests was any reaction observed. The solutions whose conductivities were measured range in the case of potassium sulphate from 1 to 0.1 gr.-eq. per litre and from 0.02 to 0.0066, and in the case of magnesium sulphate from 2 to 0.4, and from 0.025 to 0.008 gr.-eq. per litre. All the determinations by Kohlrausch which lie within these limits agree with the writer's within the latter's limits of error, except the value for the solution of magnesium sulphate of concentration 0.5, the conductivity of which, as measured by the writer, is 0.6 per cent. less than the value given by Kohlrausch. This difference was found to hold in the case of four specimens of recrystallized salt, both Eimer & Amend's and Merck's. The error of the writer's determination in this case might be 0.4 per cent.

In the first attempts to prepare the double salt, the K_2SO_4 and $MgSO_4$ were brought together in equimolecular, or nearly equimolecular proportions. In the case of the salt numbered I below the solution thus obtained was evaporated until crystals began to form. It was then allowed to cool to 75°C. and kept at a temperature varying from 60°C. to 75°C., until a large part of the salt had crystallized out. The crystals were dried on filter paper, and a portion heated in a platinum crucible to a dull red heat, until the weight was constant. The amount of SO_4 in the dry salt was then determined. The second specimen was crystallized out from a solution containing a small excess of $MgSO_4$, and was treated in a similar manner, except that the drying on filter paper was omitted. The third specimen was recrystallized according to a method given in its essentials in Dittmar's Quantitative Analysis. 87.1 grammes of powdered recrystallized K_2SO_4, together with 153.4 gms. of Eimer & Amend's chemically pure $MgSO_4 + 7\ H_2O$, which had not, however, been recrystallized by the writer, were dissolved in 350 grammes of hot distilled water. The solution was made up to about 645 grammes, and after it had cooled to 50°C, put in a porcelain basin and left 24 hours. The crystals thus obtained were washed in pure water, powdered, and then dried on filter paper and by exposure to the

air. The following table shows the proportions in which the two salts were brought together, and the percentage of SO_4 obtained by analysis of the salt freed from the water of crystallization. By theory the percentage should be 65.27 :—

	K_2SO_4	$MgSO_4$	Percentage of SO_4	Difference per cent. from theoretical value.
I	1	1.	64.31	−1.5
II	1	1.038	65.00	−0.4
III	1	1.13	65.47	+0.3

The error in a single analysis might be 0.2 per cent. The constitution of the specimens used was determined from two analyses. The salt used in the double salt determinations was the specimen III., and another portion of salt prepared similarly to it and which showed the same excess of SO_4. This excess was probably due to the fact that the double salt was crystallized out of a solution containing an excess of 13 per cent. of $MgSO_4$, an excess of which, however, is necessary to prevent the formation of K_2SO_4 crystals along with those of the double salt.

Of the double salt solutions referred to in the tables below, those *in italics* were made up in the cell itself by the addition of 5 c. c. of water each time in the case of the solutions above 0.1 gr.-eq. per litre, the original quantity having been 100 c.c. The other solutions were made up outside the cell and allowed to remain for some time before their conductivity was measured. To obtain equimolecular mixtures of the simple solutions, two solutions of K_2SO_4 and $MgSO_4$ were made up, of nearly the same concentration. Each of these was carefully analyzed, the difference being found to be 0.2 per cent. The proper amount of water was then added to the stronger solution to make the two equimolecular. Other solutions were made up by diluting these, the same pipette and flask being used in each case to dilute the K_2SO_4 and $MgSO_4$ solutions to the same extent. Mixtures of equal volumes were then made in order to obtain equimolecular mixtures of solutions of the two salts. The conductivities of these were measured within at most four hours after they had been made up.

Distilled water was used in making up all the solutions. In the case of the very dilute solutions, the conductivity of the water used was subtracted from the measured conductivity of the solution. The greatest value of this correction was 0.2 per cent.

The combined error in the determination of the conductivity and concentration of a double salt solution might be for solutions of concentration 0.4 gr.-eq. per litre, 0.3 per cent., for 0.8 solutions, 0.4 per cent., and for the very dilute solutions, from 0.02 downwards, 0.8 per cent. The errors in the case of the stronger simple solutions might be 0.2 per cent. greater. The error in plotting results and calculating from them by Professor MacGregor's graphical process might be 0.2 per cent.

Kohlrausch's values of the molecular conductivity at infinite dilution, were used in the calculations. They are, for potassium sulphate 1270, for magnesium sulphate 1080, expressed in terms of 10^{-8} times the conductivity of mercury at 0°C.

The following table gives the results of the measurements of simple solutions, made to secure data for the subsequent calculations. The concentrations are given in gramme-equivalents per litre at 18°C. The conductivities are for the temperature 18°C., and are expressed in terms of the conductivity of mercury at 0°C. multiplied by 10^{-8} :—

Potassium Sulphate. ½ $K_2 SO_4$.		Magnesium Sulphate. ½ $Mg SO_4$.	
Concentration.	Conductivity.	Concentration.	Conductivity.
.9980	668.6	2.017	404.7
.9509	640.5	1.922	396.1
.9078	616.9	1.837	386.6
.8688	596.1	1.759	378.4
.8327	575.6	1.687	370.9
.7975	555.0	1.622	363.6
.7604	533.2	1.388	333.1
.7264	513.1	1.324	323.4
.6955	491.5	1.266	314.9
.6671	474.1	1.212	305.9
.6662	472.8	1.001	270.6
.6251	446.1	.9384	259.0
.5889	427.3	.8837	248.3
.5568	405.8	.8345	239.0
.5281	387.2	.7913	230.7
.5029	369.6	.7520	222.1
.5016	369.7	.7050	211.8
.4992	369.4	.6636	201.8
.4542	341.0	.6268	194.4
.4166	316.4	.6146	191.1
.3852	294.9	.5805	182.6
.3580	274.9	.5510	175.9
.3347	259.0	.5227	168.8
.3344	260.1	.5224	168.9
.3136	246.1	.5028	164.8
.2954	233.5	.4997	163.6
.2991	222.3	.4751	158.3
.2645	211.4	.4545	152.9
.2514	201.1	.4356	147.8
.2508	201.2	.02516	15.43
.2091	171.0	.02359	14.61
.0999	89.43	.02220	13.91
.0200	20.76	.02097	13.32
.01668	17.70	.02012	12.76
.01430	15.32	.01678	11.07
.01001	11.00	.01438	9.679
.008340	9.226	.01260	8.659
.007706	8.581	.01121	7.861
.006680	7.509	.01009	7.273
.006706	7.517	.01007	7.185
		.008395	6.156
		.007754	5.773

The following tables show the results of the calculation of the conductivities of the double salt solutions and of the equimolecular mixtures:

Concentration.	Concentration of ions.	Regional Dilution.		Conductivity.		
		$\frac{1}{2}K_2SO_4$.	$\frac{1}{2}MgSO_4$.	Calculated.	Measured.	Difference per cent.
Double Salt Solutions ($\frac{1}{4}MgK_2(SO_4)_2$.						
1.001	.3734	1.499	.4996	456.5	451.4	+1.1
.8345	.3266	1.747	.6500	398.0	393.5	+1.2
.6688	.2757	2.127	.8640	335.0	331.6	+1.0
.5019	.2191	2.768	1.216	265.5	261.6	+1.5
.4705	.2073	2.938	1.312	251.2	249.8	+ .6
.4429	,1976	3.113	1.403	239.3	237.3	+ .8
.4183	.1884	3.284	1.498	228.0	227.0	+ .4
.3963	.1800	3.459	1.593	218.0	216.7	+ .8
.3765	.1721	3.626	1.687	208.1	206 9	+ .6
.02004	.01408	59.34	40.42	16.79	16.73	+ .4
.01671	.01199	70.54	49.08	14.29	14.36	− .5
.01433	.01045	81.63	57.87	12.45	12.46	− .1
.01255	.009305	92.47	66.80	11.07	11.08	− .1
.01116	.008364	103.6	75.63	9.960	9.977	− .2
.01004	.007614	I14.4	84.62	9.063	9.009	+ .6
.009972	.007558	115.3	85.33	8.987	9.009	− .3
.008318	.006421	136.9	103.3	7.632	7.665	− .4
.00714	.00599	158.6	121.7	6.640	6.660	− .3
Equimolecular Mixtures.						
1.002	.3734	1.499	.4996	456.4	451	+1-2
.6690	.2757	2.127	.8640	334.9	327.8	+2.1
.5003	.2184	2.777	1.220	264.7	258.6	+2.3
.0200	.01406	59.47	40.51	16.76	16.64	+ .7
.01001	.07584	114.8	85.02	9.021	9.024	− .05

The columns in order give (1) the concentrations, in gramme-equivalents per litre, of the double salt solutions, or of the

constituent simple solutions of the equi-molecular mixtures, as the case may be; (2) their concentrations of ions; (3) the dilutions, in litres per gramme-equivalent, of the respective salts in the regions of the solutions occupied by them, determined by the graphical process referred to above, on the hypothesis that the salts exist separately, (4) the values of the conductivities as measured, and (5) as calculated, and (6) the excess per cent. of the former values over the latter. The concentrations of ions, that is the ionization coefficients divided by the dilutions, and the conductivities, are given in terms of the units before specified. The solutions, the values of whose concentrations are printed in italics, were made up in the cell.

In the case of the double salt solutions from 1 gr.-eq. per litre down to 0.4, the values of the conductivities are less than they would be if the salts were separated, as judged from the values calculated on that hypothesis. For this range of solutions the signs in the last column are all positive, and the differences are beyond the limits of error, though in two cases not much beyond. With the first four solutions the excess of the calculated values does not differ much, though the fourth is unexpectedly high. On the first addition of water to the 0.5019 solution, the difference becomes much smaller and continues so as water is added. Moreover, with most of the solutions from 0.5 to 0.37, that is, with the solutions which were diluted in the cell, the conductivity rose after the water had been added and mixed. In these cases the last value observed was taken as the conductivity of the solution. Thus the first measurement of the conductivity of the 0 4075 solution gives a value 1 per cent. less than the calculated value; but the last two measurements of the same solution taken half an hour later give a value only 0.6 per cent. less. In the case of the 0.4183 solution, however, no change was noticed. The effect is as if the addition of water, and possibly also the stirring of the solution, caused the double salt to undergo rapid dissociation. But it may have been due to the thorough mixture of the original solution and the water added, requiring time.

In the case of the dilute solutions the differences are within limits of error, although their signs are not entirely satisfactory

most of the signs being negative. The results of these measurements seem to show that at such dilution the double salt is separated into its components.

The conductivities of the strong double salt solutions seem to be greater than the conductivities of corresponding mixtures, though in the case of dilute solutions they agree.

A fact which makes the writer somewhat suspicious of the trustworthiness of the measurements of the mixtures of strong solutions is that the density of these mixtures was found to be less than the mean density of the constituent solutions, amounting at the concentration 0.8 to a difference of 0.1 per cent. The error of a density measurement might be 0.03 per cent. The density of the double salt solutions was found to be equal to the mean density of the K_2SO_4 and $MgSO_4$ solutions of the same strength. The following are the measurements on which these statements are based. With the exception of those for the $MgSO_4$ solutions, the values of which are taken from Kohlrausch and Hallwachs' determinations, they were made by the writer.

½ K_2SO_4.		½ $MgSO_4$.		Double Salt.		Equimolecular Mixtures.	
Gr.-eq. per litre.	Sp. Grav. at 18°.	Gr.-eq. per litre.	Sp. Grav. at 18°.	Gr.-eq. per litre.	Sp. Grav. at 18°.	Gr.-eq. per litre.	Sp. Grav. at 18°.
.8327	1.0567	1.	1.05863	1.001	1.0633	.8019	1.0503
.7975	1.0539	.5	1.02987	.8345	1.0531	.6690	1.0422
.6688	1.0456	.25	1.01518	.6688	1.0427	.5003	1.0317
.5029	1.0344	.01	1.00063	.3744	1.0243	......	......
.5016	1.0340	.....	.....	.0998	1.0040	......	......
.2508	1.0173	......	......	.02004	1.0015	.....	......
.01001	1.0006	.....	......	.01004	1.0004	......	.....

The results of the double salt measurements lead the writer to conclude that in dilute solutions the double salt entirely separates, but that in strong solutions the two component salts are at least partly united.

VII.—TRIASSIC (?) ROCKS OF DIGBY BASIN.—BY PROF. L. W. BAILEY, LL. D., F. R. S. C., *Fredericton, N. B.*

(Read May 10th, 1898.)

In the course of a geological survey of the south-western counties of Nova Scotia, of which the results form the substance of a report soon to be issued by the Geological Department at Ottawa, several interesting questions in connection with the rocks of the Annapolis Valley were brought to notice, but as to which the data obtainable at the time were not sufficiently complete to warrant definite conclusions. It was hoped that opportunities for further study would be available, but as this, so far as concerns the writer, does not now seem probable, he has thought it well, in the following notes, to make brief reference to the nature of these questions, that others interested in the geology of this part of the Province, and more favorably situated than he, may be able to give them further attention.

It has been usual to regard all the rocks of the Annapolis Valley, other than those which form its southern wall, as being of Triassic age, and, further, as embracing a sedimentary and a volcanic series of which the latter was altogether the more recent and overlaid the former. A close examination of some sections in the vicinity of Digby tend to modify the second at least of these conclusions.

The first section to which reference is made is to be found in the parish of Granville, on the eastern side of Digby Gut. From the point where the latter suddenly expands to form Annapolis Basin, the shore, for nearly half a mile to the northward, shows a series of low bluffs of a bright red colour, in connection with which at some places may be seen ledges of very soft red shales. In going northward along the Gut shore and approaching the high trappean hill whose face has been laid bare by an extensive land slide, similar red beds continue to show, but become some-

what pebbly. They are nearly horizontal, but with the frequent occurrence of what appears to be false bedding. Still farther north they become, within a few yards, quite coarse, while the colour changes from red to chocolate brown, more or less mottled with light grey. The paste is soft and clayey, but imbedded in the latter, in addition to masses of red sandstone, are numerous *columnar blocks of trap.* These blocks are markedly prismatic and of considerable size, one of them, as shown in the accompanying sketch, projecting from the face of the bluff for over two feet. What is the age of these beds?

Evidently they are newer than the trap of which they contain imbedded columns. But how much newer? Possibly Quaternary. Regarded solely by themselves, there would seem to be no great objection to this conclusion, and it is favored by the occurrence in the vicinity of beds filled with trappean blocks which bear every evidence of being of this age, but the latter are of a different colour, and do not show that intimate association with the Triassic beds which characterizes the former. This association is well exhibited in the accompanying sketch, made upon the ground. (*See* Plate X, Fig. 2.)

The lowest beds exposed at this point are brownish red sandstones, horizontally stratified, and no doubt a continuation of those seen along the Granville shore. Resting upon them, but somewhat irregularly, are beds of purplish red conglomerate, which are also obscurely stratified, but seem to pass upwards into the very coarse conglomerate in which are contained the large blocks of trap. Between the two there is no clear line of separation as regards either colour or texture. The coarse beds are, however, exposed only for a few yards, while beyond them the finer beds, somewhat mottled, show at intervals for nearly a furlong. In this latter direction they form the shore beneath the high hill of columnar trap to which reference has been made, but owing to the land-slide which has affected the face of the latter, the relations of the one to the other are not easily to be made out. The purplish grey beds along the shore would seem, from their position, to extend beneath the trappean hill, but in

following the former along the shore for a short distance they are found, after becoming gradually harder and somewhat vesicular, to terminate abruptly along a vertical line, which would appear to be a line of fault, the only rocks seen beyond it, but in loose blocks, being composed of trap.

From a review of the above conditions it would seem to be at least possible that the red and purple beds, which are undoubtedly a part of the group usually referred to the Trias, are more recent than the neighboring traps, unless indeed there were several periods of eruption, between or during which the stratified rocks were deposited, and then received their burden of trappean fragments.

We have now to notice another section in which facts of a similar character are still more clearly exhibited.

This second section is found in the town of Digby, just below the point where the track of the Dominion Atlantic Railway, in taking the direction of Bear River, runs along the top of a series of low bluffs overlooking the Annapolis Basin. One of them, about twenty feet high, is nearly vertical and almost wholly composed of rock, exhibiting the arrangement reproduced in the accompanying diagram. (*See* Plate X, Fig. 1.)

At the summit are about two feet of soil, consisting of a reddish sandy loam. This rests upon a bed which in texture resembles a coarse gravel, but with the pebbles contained in a matrix which, while sandy, is compact, and bleached to a light grey colour by the action of humus acids from above. The pebbles in this bed include traps similar to those of the North Mountains, both crystalline and amygdaloidal, besides granite and slate; and, as in the case of some of the beds on the Granville shore, they suggest a Quaternary origin. But directly beneath is a bed of reddish grey sandstone, several feet in thickness, which as clearly belongs to a much earlier formation, and in one particular only differs from the ordinary red sandstones of the Annapolis valley. *It also contains, but not uniformly, blocks of North Mountain trap.* Further, below this red sandstone bed, but at the northern end of the section, and merging into it,

is another coarse pebble-bed, in which the trappean blocks are very abundant and of large size. Finally, the base of the section, at its southern end (the whole section being about 30 feet in length) shows another bed of red sandstone, about two feet thick, and quite free from pebbles, while at the other extremity repeated alternations of beds with and without the trappean blocks may be seen. The lower part of the section is here obscured by a talus.

It seems very certain, from what is here exhibited, that while the trappean overflows along the Bay of Fundy trough were in part and perhaps largely subsequent to the accumulation of the Triassic red sandstones, as so clearly seen at Blomidon, they must also in part have antedated or else been contemporaneous with the deposition of red sandy sediments usually regarded as of the same age with the former.

As having, perhaps, some bearing upon this interesting question, reference may here be made to a curious section to be seen near the south-western end of the island of Grand Manan, of which, as is well known, so large a part consists of Triassic traps. The more exact location of the section is in the settlement of Red Head, at the south-west extremity of the relatively low tract of old (Huronian ?) rocks underlying the inhabited portions of the island, and to the south of the trappean ridge extending thence to the Southern Head. The older rocks referred to are hard, rubbly, dark grey slates, which are often greenish or chloritic, and much stained, sometimes ribbanded with oxide of iron. They are greatly contorted, but have a general north-west dip at a high angle. Resting on these slates, but without any distinct bedding, is a quantity of breccia or conglomerate, filled with blocks, both rounded and angular, of trap and slate. Then follows a mass of more solid trap, which is partly columnar, and into this the conglomerate or breccia seems to graduate.

About fifty feet to the north of the above exposures, a second and much more conspicuous bed (?) of breccia is seen, (Plate X, Fig. 3), *flanked on either side by solid columnar trap,* the conglomerate being about 10 feet wide and rising almost

perpendicularly, making a very marked appearance in the face of the cliff, and having much of the aspect of a dyke. It is, however, wholly made up of detached blocks,—some of them two or three feet long,—of the same nature, and some of them exhibiting the prismatic shape of the trap columns near by. In some instances, however, they are rounded. No trace of the ordinary red sandstones or of any beds resembling those about Digby is to be seen.

It seems hardly possible that the material of this agglomerate should have received its present position except through introduction from above into a previously opened fissure; but whether introduced contemporaneously with the lava flows and ash accumulations represented in the neighboring dolerites and amygdaloids, *i. e.*, in the Trias-Jura epoch, or later and possibly in the Quaternary, is a question which the writer is at present unable to answer.

Reviewing the entire subject, it is evident that there are still some unsolved problems in connection with the supposed Mesozoic rocks of the Bay of Fundy trough (including in the latter the Annapolis Basin); and if the observations here given prove the means of originating any further enquiries in this direction, the purpose of this paper will have been served.

VIII.—The Flora of Newfoundland, Labrador, and St. Pierre et Miquelon: Part III.—By the Rev. Arthur C. Waghorne, *Bay of Islands, Newfoundland.*

(Read May 9th, 1898.)

A change of residence, and the charge of a new and extensive parish, are the hindrances which are chiefly accountable for the delay in the continuance of this series of papers, of which the first part appeared in the *Transactions* of the Institute, Vol. VIII (Ser. 2, Vol. I.), page 359; and the second part in Vol. IX (Ser. 2, Vol. II.), page 17.

To the prefatory remarks of the two preceding papers, a few notes should here be added:—

1. The Part I. here first presented is made up of Polypetalous plants which have been added to our Newfoundland or Labrador lists of plants since 1895.

2. These have been obtained from three sources, chiefly:—

(a) Professor Macoun's *Contributions from the Herbarium of the Geological Survey of Canada,* (Parts I.—VI.); these are indicated herein briefly as "C. H. Geo. S. of C."

(b) A list of Newfoundland plants collected by Mr. A. B. Bullman, B. A. Sc. (of H. M. Newfoundland Survey). The plants were collected by him on the West coast in 1896, and in White Bay in 1897. This gentlemen modestly says that he lays no claim to be a botanist, so that his determinations may be subject to revision, a fate which befalls even those of men who *are* botanists. If Mr. Bullman's decisions are sustained as to certain plants, his list adds fifteen names to our flora.

(c) My own collections since 1895 in the Bay of Islands, and a week while in Bay St. George, and a trip across the country in 1895, and to Brenton and Clode Sound in Bonavista Bay, on the East coast. At Mr. Reid's stone quarry, about 80 miles from the Bay of Islands, on both sides of the railway track, by the

sides of the ponds in the bogs, I was fortunate enough to find, for the first time, the Schizæa pusilla, Pursh, in fair quantity.

3. To the gentlemen who have kindly assisted me in the determination of my plants, I may now add the names of Dr. Wm. Trelease of St. Louis, Dr. B. L. Robinson of Harvard, and Mr. T. V. Coville of Washington.

4. If permitted so to do, I would gladly say that I have been for the last three or four years distributing my plants, including mosses and lichens, (the fungi I hope to have ready this coming season), and that I should be glad to hear of any who may desire specimens.

I.—POLYPETALÆ. (Supplementary to Parts I. and II.)

I.—RANUNCULACEÆ.

265. *Anemone nemorosa*, L. WOOD ANEMONE. Deer Arm, Bonne Bay (Bullman). Moist places. July.

7. *Ranunculus abortivus*, L. Var. *micranthus*, Gray. Chimney Cove, B. of I., (A. C. W.—Fowler). Sea cliffs. June.

266. *R. septentrionalis*, Poir. Near Meadows, B. of I. (A. W. Trelease), and Deer Lake (according to Dr. Robinson, but this plant was named R. Macounii by Dr. Trelease). Meadows and wet places. July.

267. *R. Macounii*, Brit. Chimney Cove, B. of I. (A. C. W.—Trelease). Fields. July.

268. *R. fasicularis*, Muhl. Birchy Cove, B. of I. (A. C. W.—Trelease. Fields. June. (Dr. Robinson says this is R. repens, L.)

19. *R. recurvatus*, Poir. Humber River (A. C. W.—Fowler). River side. June.

IV.—MENISPERMACEÆ.

269. *Menispermum Canadense*, Pointe Lafontane, West Coast (Bullman). Low ground. June.

VII.—CRUCIFERÆ.

270. *Erysimum asperum*, D. C. Chimney Cove, B. of I. (A. C. W.—Fowler). Sea cliffs. June.

271. *Arabis lævigata*, Poir. SMOOTH ROCK CRESS. Cow Head (Bullman). Dry, rocky ground. June.

36. *Barbarea vulgaris*, R. Br. Mentioned in Prof. Macoun's C. H. Geo. S. of C. (V. 2) as not before recorded from the Labrador, was twice collected by the compiler in 1894 in the Straits of Belle Isle. *See* Part II., p. 20.

138. *Nasturtium palustre*, D. C. To the Labrador reference in Part I., p. 20, may now be added its Newfoundland occurrence at Deer Lake (A. C. W.—Fowler). River side. August.

272. *Cardamine Pennsylvanica*, Muhl. Whitbourne, appearing introduced (R. & S.).

273. *Hesperis matronalis*, L. Street of St. John's; infrequent (R. & S.)

274. *Subuleria aquatica*, L. Terrestrial form. Exploits River and around pond near Whitbourne (R. & S.). August.

VIII.—VIOLACEÆ.

62. *Viola palustris*, L. Though recorded in Part I., p. 9, from the Labrador (named by himself), this is mentioned in Prof. Macoun's C. H. Geo. S. of C. (V. 2), as not before (1894) recorded from Labrador.

65. *V. canina, L. Muhlenbergii.* In Bay of Islands at Birchy Cove (Fowler), Coal River and Lark Harbour (Robinson), and Rope Cove (Trelease). Fields and wet places. June.

XIV.—CARYOPHYLLACEÆ.

275. *Silene Armeria*, L. Deer Lake (A. C. W.—Fowler). Near gardens. August.

276. *Arenaria Sajanensis*, Willd. Coal River, near B of I. (A. C. W.—Robinson). Sandy places. July. *Lab:* Cape Chidley (C. H. Geo. S. of C., V. 5).

69. *A. verna*, L. Englee, White Bay, and Coal River, B. of I. (A. C. W.—Fowler). June.

var. hirta, Bigel. Coal River (A. C. W.—Fowler). Sandy places. June.

277. *A. patula*, Mx. Chimney Cove, B. of I. Hills. June. (Dr. Robinson says, *A. verna*, L.).

278. *A. ciliata*, L., var. *A. humifusa*, Hornen. Coal River (A. C. W.—Robinson). Sandy places. July.

89. *Stellaria borealis*, Bigel. Var. *alpestris*, Gray. Shoal Point, B. of I. (A. C. W.—Trelease); Dr. Robinson says "this is very different from Dr. Gray's conception and is much better considered only as *S. borealis*, L."

XVI.—HYPERICACEÆ.

104. *Hypericum Canadense*, L. Var. *miserrimum*, Chois. Seal Rocks, Sandy Point, Bay St. George (A. C. W.—Fowler) Wet places. August.

XVII.—GERANIACEÆ.

279. *Geranium Robertianum*, L. Chimney Cove, near Bay of I. (A. C. W.—Fowler). Ravines. July.

110. *Oxalis acetosella*, L. To the doubtful occurrence referred to in my Part I, 13, may now be added Portland Creek, White Bay (Bullman). Woods. June.

XX.—LEGUMINOSÆ.

280. *Astragalus astragalinus*, D. C. *Minnesota Botanical Studies*. Bull. IX., p. 65.

117. *A. alpinus*, L. Chimney Cove, B. of I. (A. C. W.—Trelease). High seacliffs. July. Professor Shelden (St. Louis) refers this to *Spiesia Lamberti* (Pursh), *v. spicata*. Hook.

124. *Oxytropis campestris*, D. C. Chimney Cove (A. C. W. Fowler and Robinson). Hills. July and August. And White Bay (Bullman). Stony Shore.

119. *Hedysarum boreale*, Muhl. Wild Cove, near B. of I. (A. C. W.—Trelease). Sea bank. July.

XXXII.—ROSACEÆ.

281. *Gillenia trifoliata,* Moench. Ponds River, West Coast. (Bullman). Woods. June.

282. *Agrimonia striata,* Mx. Chimney Cove, B. of I. (A. C. W.—Shelden). Hills. July. Reported as *A. Eupatoria* by Prof. Fowler.

283. *A. hirsuta,* Wilds. Chimney Cove (A. C. W.—Robinson). High hills. August.

253. *Fragaria vesca,* L., var. *Americana,* Porter. Chimney Cove (A. C. W.—Trelease). Banks. July.

284. *Geum album,* Gmel. Cow Head, Bonne Bay (Bullman). Woods. June.

285. *Potentilla litoralis,* Rydberg. Chimney Cove, B. of I. (A. C. W.—Robinson). Hills. August. Reported by Dr. Fowler as *P. Pennsylvanica,* L.

179. *Rosa Carolina,* L. The reference to this from New Harbor (Part II., p. 25) should have been marked as very doubtfully named by Prof Macoun. M. Crepin says it must be omitted.

286. *R. humilis,* Marsh. Shoal Point, near Bay of Islands (A. C. W.—Dr. G. N. Bert). St. John's (Robinson and Schenk). Woods. August.

XXXIII.—SAXIFRAGACEÆ.

201. *Ribes rubrum,* L., var. *subglandulosum,* Maxim. Crabbs (Fowler) and Frenchman's Cove (Robinson), B. of I. (A. C. W.) Woods. June.

287. *Ribes floridum, Wild Black Currant.* Cow Head (Bullman). June.

197. *Parnassia parviflora,* D. C. Chimney Cove (Robinson), and Goose Arm, B. of I. (Fowler). A. C. W. Hills and wet banks. August.

XXXV.—DROSERACEÆ.

220. *Drosera intermedia,* Drev. and Hayne. Var. *Americana,* D. C. *Lab:* Upper West Branch, Hamilton River (A. P. Low, 1894, C. H. Geo. S. of C., V. 6.)

XXVIII.—RHAMNACEÆ. *(Buckthorn Family).*

288. *Rhamnus alnifolia*, L'Her. Deer Lake (Fowler) and Lark Harbour, B. of I., (A. C. W.), Woods. July.

XXXVI.—HAMAMELACEÆ. *Water-hazel Family.*

289. *Hamamelis Virginiana*, L. Cow Head, Bonne Bay (Bullman). Woods. July.

XI.—LYTHRACEÆ.

290. *Nesæa verticillata*, H. B. K. ? St. John's Island, St. John's Bay, West Coast. (Bullman). July.

XLV.—UMBELLIFERÆ.

250. *Osmorrhiza brevistylis*, D. C. Frenchman's Cove, B. of I. (A. C. W.—Fowler). Woods. June and July.

251. *Sanicula Canadensis*, L. Wild Cove (Trelease), and Shoal Point, B. of I. (Fowler) A. C. W. Banks. July. Mr. Fernand says of the Wild Cove specimen that it is better considered as *S. Marylandica*, L.

GAMOPETALÆ.

XLVIII.—CAPRIFOLIACEÆ. *Honeysuckle Family.*

275. *Diervilla trifida*, Mœnch. *Bush Honeysuckle.* S. John's. Common (Robinson and Schrenk). Brigus (Bell., Cat. III., 540); Nipper's Harbour (Notre Dame Bay) and near Badger's Brook, Exploits River (both of these collected by Revd. J. H. Bull, named by Messrs. Macoun and Fowler). Topsail (A. C. W. —Macoun). Rocky hills. July and August. *Flora Miq.*, on little hillocks near the Brook Sylvain.

276. *Linnœa borealis*, L. *Twin-flower* (GROUND-IVY AND TRUMPET-FLOWER) appear to be pretty common throughout Newfoundland and the Labrador, in mossy woods. Reported from Trinity Bay, S. John's, Fortune Bay, White Bay, Bay St. George, and Bay of Islands. *Lab :* Hopedale (Weiz-Packard);

collected at Pack's Harbour and Forteau by myself, and by Mr. Butler, on hillside. July and August. *Flora Miq.*

277. *Lonicera cœrulea*, L. *Mountain Honeysuckle* (Cat. II., 198); (Reeks); West of Random. In full fruit September 10. Cormach, S. John's (Miss Southcott); New Harbour and Green's Harbour, (Trinity Bay), and Harbour Breton (Fortune Bay); collected by myself and named by Prof. Macoun. Rope Cove, B. of I. (Fowler). Whitbourne (Robinson and Schrenk). Long Point, north of Cape St. George (Bell). Bogs and wet woods. July and August. *Lab:* (Cat. II., 198), found by myself at Indian Harbour (near Battle Harbour), and Battle Harbour, and L'anse au Loup, and Blanc Sablon, (determined by Professors Macoun and Fowler). Caribou Island (Butler-Packard). July.

Var. villosa, T. & G., (Cat. II., 198, "Newfoundland (Pylaie), Coast of *Labrador* (McGill College, Herb)").

278. *L. oblongifolia*, Hook. *Swamp Honeysuckle.* Great Cod Roy River (Bell).

279. *Sambucus racemosa*, L. *Red-berried Elder.* Random (Trinity Bay), Bay Despair (Hermitage Bay), Swan Island (Notre Dame Bay), and Bay of Islands. Collected by myself and named by Messrs. Macoun, Fowler and Morton). Woods. July.

Var. pubens, Wats. (which Prof. Macoun [Cat. III., 537] unites with the last), near Flat Bay Brook (Bell), and S. John's (Miss Southcott—Macoun).

280. *Viburnum Lentago*, L. *Sweet Viburnum, Sheep Berry.* Near Flat Bay Brook, Bay St. George, and Humber River, B. of I. (Bell). June and July.

281. *V. cassinoides*, T. & G. *Withe Rod.* (Cat. II., 194). This appears to be common in woods throughout the country. I have it reported from Trinity Bay, S. John's, Bay Despair, Hermitage Bay, and several places about Bay of Islands. July and August. *Flora Miq.*

282. *V. pauciflorum*, Pylaie. *Few-Flowered Viburnum or Arrow-wood* (SQUASH BERRY). Several places in Fortune and

Trinity Bays, Bay of Islands, S. John's (Miss Southcott). Petty Harbour (Reeks). Great Cod Roy River, Bay S. George (Bell). Manuel's River, Conception Bay (Robinson and Schrenk). Rocky banks near brooks in woods. June—August. *Lab:* ravines (Butler, Cat. II., 195.)

283. *V. Opulus*, L. *High-Bush Cranberry* (called *TRASH BERRY, I believe by Newfoundlanders mostly). Not so common as the last. Topsail (Bell, Cat. III., 539). Swamps near confluence of Exploit and Badger's River (Robinson and Schrenk). Great Cod Roy River (Bay S. George), Humber River and island in Deer Pond (B. of I.), Bell; (Reeks). July and August.

284. *V. acerifolium*, L. *Maple-leaved Arrow-wood.* Near Flat Bay Brook, Bay St. George (Bell). June.

XI.—RUBIACEÆ. *Madder Family.*

285. *Galium boreale*, L. *Northern Bedstraw* (Reeks).

286. *G. asprellum*, Mx. *Rough Bedstraw.* Whitbourne (Robinson and Schrenk); Bay Bull's Arm (Trinity Bay) and Shoal Point, B. of I. (A. C. W.—Macoun and Fowler); (Reeks). Woods and moist ground. August.

287. *G. trifidum*, Mx. *Small Bedstraw.* In the Bay of Islands, collected by myself, at Riverhead (Fowler), and Lark Harbour (Robinson), Benton, Bonavista Bay (Fowler); several places in Trinity Bay, and Topsail in Conception Bay (Fowler and Macoun). Wayside and wet places. August. *Lab:* Hopedale (Weiz-Packard); Forteau (A. C. W.—Eaton). August.

Var. pusillum, Gray. Sunny banks, Whitbourne (Robinson and Schrenk); White Bay or Ferryland (Revd. R. Temple—Fowler). *Lab:* Forteau (A. C. W.—Fowler and Butler). June and July.

Var. tinctorium, T. & G. (Cat. II., 201).

Var. latifolium, Torr. Open woods, S. John's (Robinson and Schrenk). August.

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* The "Joint-wood Berry" and "White-wood Berry" of Newfoundland, must, I think, be this, or one other of this genus.

288. *G. Aparine*, L. *Goosegrass.* Middle Arm, B. of I. (A. C. W.—Fowler). Woods. July.

289. *G. triflorum*, Mx. *Three-flowered Galium.* Near confluence of Exploits and Badger's River (Robinson and Schrenk); New Harbour, Trinity Bay (Macoun); and Wild Cove (Fowler), and Chimney Cove (Trelease). Woods. July. *Lab:* Capstan Island (A. C. W.—Eaton). Open woods. July.

290. *G. Mollugo*, L. *Narrow-leaved Bedstraw.* S. John's (Robinson and Schrenk). Ploughed ground. August.

291. *G. palustre*, L. var. *minus*, Lge. *Lab:* Long Point, Hamilton Island (A. C. W.—Macoun), (C. H. Geo. S. of C., IV. 202).

292. *Mitchella repens*, L. *Partridge berry.* (Reeks); Flat Bay Brook (Bell). *Flora Miq.*, found once near stream Bibite, in damp ground, in August. Sought after by the partridges of the island.

I.—Valerianaceæ. *Valerian Family.*

293. *Valeriana dioica*, L. var. *sylvatica*, Wats. *Marsh Valerian* (Banks, Cat. III., 204).

III.—Compositæ. *Composite Family.*

294. *Achillea Millefolium*, L. *Yarrow. Milfoil (Dead Man's Daisy).* Common in fields. *Lab:* Forteau. August, (rose-coloured). *Flora Miq.*, common, July, August.

Var. nigrescens, E. Meyer. *Lab:* Nain (Bell, Cat. III., 552), Caribou Island (Butler), and Hopedale (Weiz-Packard.)

295. *A. Ptarmica*, L. Introduced, Harbour Grace (McGill Coll.. Herb.—Cat. II., 251).

296. *Arnica alpina*, Murr. *Lab:* Nachvak and Cape Chimney (Bell) Cat. II., 261; III., 535.

297. *Antennaria alpina*, L. *Everlasting. Lab:* (Kolmeister —Cat. II., 236), Hopedale (Weiz), and Caribou Island (Butler) Packard.

298. *A. Carpathica*, R. Br. Wet, boggy places and river margins, (Gray) Cat. II., 237.

299. *A. dioica*, Gaertn. *Mountain Cudweed or Everlasting.* From Newfoundland to *Labrador*, and the extreme Arctic regions and dry mountain pastures of the Rocky Mountains (Cat. II., 236). S. John's (Miss Southcott); Exploits (A. C. W. —Fowler). Rocky banks. July.

300. *A. plantaginifolia*, Hook. (Reeks), Badger's Brook (Revd. I. H. Bull—Fowler); Middle Arm, B. of I. Rocky bed of S. W. Arm River. Holyrood (Robinson and Schrenk). Sea cliff. Open Woods. June to September.

301. *Anaphalis margaritacea*, Benth and Hook. *Pearly Everlasting.* (Reeks). Common on dry soil along the margins of fields and borders of woods, from Newfoundland to the Pacific (Cat. II., 237). Rocky hills, S. John's and Holyrood (Robinson and Schrenk); Bay S. George (Howley and Bell). Common about B. of I. and Trinity Bay (A. C. W.) July.

302. *Artemisia borealis*, Pall. var. *spithamœæ*, T. & G. *Lab:* (Kolmeister, Cat. II., 255). Hopedale Island (Weiz-Packard).

303. *A. Canadensis*, Mx. Near Badger's Brook (Revd. I. H. Bull—Fowler); in the Bay of Islands, Middle Arm, near Rope Cove, Chimney Cove and Goose Arm (A. C. W.—Fowler and Robinson). Woods, sea cliffs, and sandy plains; dry river bed. July and August.

304. *A. Absinthium*, L. *Wormwood.* Naturalized in numerous places by roadsides, in lanes, and about dwellings, from Newfoundland to the western part of Ontario. (Gray, Cat. II., 259).

305. *Arctium Lappa*, L. *Burdock.* S. John's (Professor Holloway—Fletcher). In leaf only, but probably var. *minus*. Holyrood (Robinson and Schrenk).

306. *Anthemis arvensis*, L. *Wild Chamomile.* Random, Trinity Bay (A. C. W.—Macoun).

307. *A. Cotula*, D. C. Clode's Sound, Bonavista Bay (Robinson and Schrenk). Frenchman's Cove, B. of I. Garden weed and about buildings. August and September.

308. *Aster macrophyllus*, L. *Large-leaved Aster.* I cannot find my authority for this plant.

309. *A. Radula*, Ait. *Rasp-leaved Aster.* (Cat. II., 219). West of Random (Cormack); S. John's (Miss Southcott); New Harbour and S. Anthony, N. E. coast, (collected by myself and named by Prof. Macoun); Benton, Bonavista Bay (A. C. W.—Fowler). Rocky bank Manuel's River (Robinson and Schrenk). *Lab:* (Butler, Cat. II., 219); collected by myself at Battle Harbour and L'anse au Loup (Macoun). August and September. Wet places. *Flora Miq.*, damp marl, rarely dry places; very common.

Var. strictus, Gray. Rocky hills, S. John's; moist open ground at confluence of Exploit and Badger's River; Grand Lake, B. of I. (Robinson). *Lab:* (Pursh, Cat. II., 219); Hopedale (Weiz-Packard); Square Islands and Capstan Island (A. C. W.—Macoun and Eaton). Bogs and wet places. August.

310. *A. lævis*, L. Little Harbour, near B. of I. (A. C. W.—Trelease,—"inflorescence more corymbose and bracts more foliaceous, and not so green-tipped"). September.

311. *A. paniculatus*, L. Harbour Breton, Fortune Bay, (A. C. W.—Macoun).

312. *A. salicifolius*, Ait. Harbour Breton (A. C. W.—Macoun).

313. *A. Novi-Belgii*, L. Exploits River (Robinson and Schrenk); near Frenchman's Cove and Coal River, B. of I. (A. C. W.—Robinson). The latter was reported as *A. tardiflorus* by Prof. Fowler. Wet places. September. Vide *A. longifolius* below, No. 315.

314. *A. tardiflorus*, L. *Long-leaved Aster.* S. John's Beach and Lark Harbour, B. of I. (A. C. W.—Fowler); New Harbour, Trinity Bay, and Harbour Breton, Fortune Bay (A. C. W.—Macoun). *Lab:* (Gray, Cat. III., 545); Battle Harbour (Bull); Fox Harbour, Hawk's Bay and Cartwright (A. C. W.—Macoun); L'anse au Mort. (A. C. W.—Fowler). August and September.

315 *A. longifolius*, Law. Near meadows, B. of I. (A. C. W. —Robinson). Reported by Mr. Covelle as *A. Novæ-Angliæ. var.* banks. September.

316. *A. punicius*, L. *Red-stalked Aster* or *Starwort* (Reeks). New Harbour and Harbour Breton (A. C. W.—Macoun); river banks, Salmonier, common (Robinson and Schrenk); Benton, Bonavista Bay (A. C. W.—Fowler). Woods. August and September. *Lab:* Lake Michikamov (A. L. Low—C. H. Geo. S. of C., VI., 6); L'anse au Loup (A. C. W.—Fowler). September.

Var. lucidulus, Gray. Was named by Dr. Trelease and found in the Bay of Islands.

Var. firmus, T. & G. (=*v. levicantes*, Gray). A doubtful specimen of Mr. Howley's from Bay S. George (Macoun). *Lab:* Deep Water Creek (A. C. W.—Macoun; reported as doubtful).

Var. ? Shoal Point, B. of I. (A. C. W.—Trelease). Woods. August.

317. *A. acuminatus*, Mx. I cannot give the authority for this.

318. *A. ptarmicoides*, T. & G. S. John's Island, S. John's Bay, West Coast (Bullman). Stony hills. July.

319. *A. nemoralis*, Ait. *Wood Aster.* Harbour Grace Cat. III., 227); West of Random (Cormack); S. John's (Prof.) Holloway—Fowler); Harbour Breton (Macoun), and Seal Rocks, Sandy Point, Bay S. George (A. C. W.—Fowler); Balley Hally bog, S. John's (Robinson and Schrenk). Bogs. August. *Flora Miq.*, very common.

320. *A. linariifolius*, L. *Double-bristled Aster.* (Cormack, Cat. II., 229).

321. *A. umbellatus*, Mill. (Cat. II., 229) S. John's (Miss Southcott—Fletcher); S. George's Bay (Howley—Macoun); collected by the compiler at South Side, Harbour Grace, Harbour Breton and Bay Bull's Arm; named by Prof. Macoun, and at Clode Sound (Trelease). Common, especially along streams.

Manuel's, Conception Bay (Robinson and Schrenk). Wet places. August and September.

322. *Bidens frondosa*, L. *Common Bigger-tick, Stick Tight.* Near meadows.

323. *Centaurea Cyanus*, L. *Blue-Bottle.* Introduced, (Reek).

324. *C. nigra*, L. *Black Knapweed (Broad Weed and French Clover)* (Reeks). S. John's (Miss Southcott and R. & S.). Apsey Beach (B. of I.). Fields. July and August.

325. *Cichorium Intybus*, L. *Chicory.* S. John's. Infrequent (R. & S.).

326. *Cnicus lanceolatus*, Hoffm. *Common Roadside Thistle.* Manuel's (R. & S.); Norman's Cove, Trinity Bay, Birchy Cove, B. of I. Cleared ground, roadsides. August.

327. *C. muticus*, Pursh. *Glutinous or Swamp Thistle. Horse Tops*, in White Bay (Reeks). Englee and other places in White Bay, and New Harbour, Trinity Bay; S. Paul's Bay (Bullman); Exploit's River (R. & S.). July—September.

328. *C. pumilus*, Torr. *Pasture Thistle.* Flat Bay (Bell).

329. *C. arvensis*, Pursh. *Canada or Field Thistle.* Hopedale, Trinity Bay (Macoun), and Birchy Cove, B. of I. (A. C. W. —Fowler); Bonne Bay (Bullman); Great Cod Roy River (Bell); S. John's (R. & S.). Wayside. July—September.

330. *Chrysanthemum Leucanthemum*, L. *Great White Large Daisy*, (BACHELOR'S BUTTONS), (Reeks); S. John's, common (R. & S.); Birchy Cove, and a few other places about Bay of Islands. Pastures. July and August. *Lab:* Battle Harbour, and by paths over hill near Forteau Lighthouse (A. C. W.—Fowler). August and September.

331. *Erigeron acris*, L. *Fleabane.* *Lab:* (Torr and Gray, Cat. II., 234).

Var. *Drœbachianus*, Blytt. *Lab:* (Gray, Cat. II., 235); Hopedale (Weiz-Packard).

Var. *debilis*, Gray. *Lab:* Lab. North, and Hudson Bay (Gray, Cat. III., 548).

332. *E. Canadense*, L. *Fireweed* (Reeks).

333. *E. strigosus*, Muhl. Bay S. George (Howley—Macoun); Badger Brook (Revd. I. H. Bull—Fowler), July.

334. *E. eriocephalus*, I. Vahl. *Lab:* Cape Chidley (Bell, Cat. III., 347).

335. *E. Philadelphicus*, L. *Canadian or Common Fleabane.* (Reeks).

336. *E. uniflorus*, L. *One-flowered Fleabane. Lab:* (Kolmeister, Cat. II., 31); Nachvak and Cape Chidley (Bell, Cat. III., 549); Hopedale (Weiz-Packard).

337. *E. annuus*, Pers. One solitary specimen in oats in recently cleared land at Deer Lake (A. C. W.—Fowler). August.

338. *Erechtites hieracifolia*, Raf. *Fireweed.* Moist places in recently burnt clearings. Very common throughout Newfoundland and Canada, and extending west to the Saskatchewan (Cat. II., 262).

339. *Eupatorium purpureum*, L. *Joe Pye's weed.* The Gould's and S. John's (Miss Southcott); Bay S. George (Howley—Macoun); Topsail (Bell, Cat. III., 541). In Bay of Islands, collected by myself; Apsey Beach (Fowler); Shoal Point and Coal River (Trelease); New Harbour, Trinity Bay (A. C. W.), and Cormack, in the same Bay; Salmonier River, and "a form passing to var. *amœnum*, Gray, was collected on the Manuel's River (R. & S.)." Wet places and sea cliffs. August and September. Prof. Macoun says (Cat. III., 541):—"Our specimens of this species nearly all belong to the variety *maculatum*;" and he evidently includes Dr. Bell's Topsail plant; but all my specimens have been referred to the species itself.

340. *Gnaphalium Norvegicum*, Sunner. *Highland Cudweed. Lab:* (Torr and Gray, Cat. II., 238); Hopedale (Weiz-Packard).

341. *G. supinum*, Vill. *Mountain or Dwarf Cudweed or Everlasting.* Englee, White Bay (A. C. W.—Fowler). Banks. September. *Lab:* (Morrison, Cat. II., 238); Hopedale (Weiz-Packard).

342. *G. uliginosum*, L. *Mud or Low Cudweed.* New Harbour (A. C. W.); Summerside, B. of I., and Sandy Point, Bay S. George (A. C. W.—Fowler). Marshy meadows. Quiddi Vidi Lake, slender uliginous form, and in the bushy branched form; very abundant in burned regions, Holyrood (R. & S.). August.

343. *Hieracium pilosella*, L. *Mouse-ear Hawkweed.* S. John's (Prof. Holloway—Fowler).

344. *H. Canadense*, Mx. *Canadian Hawkweed.* Harbour Deep, White Bay. In Trinity Bay, New Harbour and Bay Bull's Arm (Macoun). In and near the Bay of Islands and Little Harbour and Grand Lake (A. C. W.—Fowler); Manuel's River (R. & S.). Lakeside, roadside, and rocky river banks. August-October. *Lab:* L'anse au Clair (A. C. W.—Fowler). August. *Flora Miq.*, damp, peaty places. Rare.

345. *H. vulgatum*, Frier. "Less frequent than the preceding, and occurring in crevices of rocks by swift streams and waterfalls, Holyrood and the cataract of the Rocky River. To all appearance, indigenous. The leaves are nearly all mottled" (R. & S.). A doubtful specimen from New Harbour (A. C. W.). August. *Lab:* (Kolmeister, Cat. II., 275); Hopedale Islands (Weiz-Packard).

346. *H. scabrum*, Mx. Bay S. George (Howley-Macoun). In Bay of Islands, Coal River, and possibly Grand Lake (A. C. W.—Fowler). September.

347. *Knautia arvensis*, Coult. *Field Knautia or Scabious* S. John's (Miss Southcott).

348. *Lactuca Canadensis*, L. *Field Lettuce.* Trinity Bay (Cormack); Harbour Breton, Fortune Bay (A. C. W.) Doubtful.

349. *L. leucophæa*, Gray. (Cat. II., 281). Bay de l'eau, Fortune Bay (Macoun), and McIver's Cove, Bay of Islands (A. C. W.—Fowler). Borders of fields. August.

350. *Leontodon autumnale*, L. *Fall Dandelion.* (HORSE DANDELION, AUGUST FLOWER). "Naturalized by becoming abundant in Newfoundland, Nova Scotia, New Brunswick and Quebec" (Cat. II., 277). Common, at any rate about Fortune

and Trinity Bay, S. John's, and the Bay of Islands (A. C. W.) Fields and roadsides. July—September. *Flora Miq.*

351. *Matricaria inodora*, L. *Wild Chamomile.* Harbour Grace (McGill Coll. Herb., Cat. II., 253). Only on rubbish heaps, S. John's (R. & S.); Trinity Bay (A. C. W.). August.

352. *Inula Helenium*, L. *Common Elecampane.* Jackson's Arm, White Bay (Bullman). Rocky ground. August.

353. *Petasites palmata*, Gray. *Butterbun, Sweet Coltsfoot.* "Swamps and shady banks of streams from Newfoundland and Labrador to Rocky Mountains (Richardson, Cat. II., 260); White Bay (Revd. S. I. Andrewes—Macoun). *Lab:* Hopedale (Weiz-Packard).

354. *Prenanthes alba*, L. *White Lettuce.* *(PIGROOT). (Cormack, Cat. II., 282). (Reeks). *Flora Miq.*, very common in bushes. August.

355. *P. serpentaria*, Pursh. *Rattlesnake Root.* Trinity Bay (Cormack), and New Harbour Brook (?) (A. C. W.); S. John's (Miss Southcott and Lady Blake), and Bay D'Espoir in Hermitage Bay; all named by Prof. Macoun. Var. *Nana*, Gray. Holyrood and S. John's (R. & S.). Rocky hillsides, 6 inches to 2½ feet high. August. *Lab:* L'anse au Clair (A. C. W.—Fowler). September.

356. *P. altissima*, L. *Tall White Lettuce.* (Reeks) (Cormack, Cat. II., 282).

357. *Onopordon Acanthium*, L. *Cotton or Scotch Thistle.* Harbour Grace (Clift).

358. *Rudbeckia hirta*, L. *Coneflower.* S. John's and Holyrood, not yet abundant, (R. & S.). Near meadows, Bay of Islands (A. C. W.—Fowler); Tiddleton, near Conception Bay (Clift—Macoun). Fields. August.

359. *Senecio aureus*, L. *Golden Groundsel, Common Ragwort.* "From Newfoundland and Labrador to the Rocky

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* *The Flora Miquelonensis* remarks on this plant,—"Pigs are very fond of the root known as the plant under the name of 'Mountain Turnip.' It gives to the flesh an excellent flavour."

Mountains and the Pacific." (Cat. II., 264); (Reeks); S. John's (Professor Holloway—Fletcher); Salmonier and near Placentia Junction (R. & S.); near Badger Brook (Bull---Fowler); by myself in the Bay of Islands at Benoit's Cove, McIver's Cove and other places (Fowler & Coville); White Bay (Macoun). Bogs. June and July. *Lab:* found by myself at Capstan Island, L'anse au Clair, and Forteau, in the Straits of Belle Isle (Fowler and Eaton). July—August.

Var. *obovatus*, T. & G. Bay East River, Hermitage Bay (Howley-Macoun).

Var. *borealis*, T. & G. *Lab:* (Gray, Cat. II., 265); Nachvak (Bell, Cat. III., 354); Hopedale Islands (Weiz-Packard).

Var. *discoideus*, Hook. *Lab:* (Pursh, Cat. III., 265); by myself at Forteau (Eaton). July.

Var. *Balsamitæ*, T. & G. Holyrood and Exploit's River (R. & S.); Chimney Cove, Birchy Cove, and on the Bay of Islands (Fowler and Robinson). June. *Lab:* at Forteau and L'anse au Mort (Fowler), and Long Point, Hamilton Inlet (Macoun); (Butler). Swamps. June—August.

360. *S. frigidus*, Less. "Newfoundland (?) and Labrador" (Gray, Cat. II., 267).

361. *S. palustris*, Hook. *Marsh Groundsel or Fleawort. Lab:* Indian Harbour, North (Revd. W. How—Macoun).

Var. *congestus*, Hook. Battle Harbour (Bull); a northern form at Seal Islands (A. C. W.); both determined by Prof. Macoun. Marshes. August.

362. *S. Pseudo-Arnica*, Less. *False Arnica.* Newfoundland and Labrador (Hooker, Cat. II., 267); Harbour Breton (Macoun), and Sandy Point, Bay S. George (Fowler); several places about the entrance to Bay of Islands (A. C. W.). *Lab*: (Butler); Hopedale Islands (Weiz-Packard); Battle Harbour (Bull—Macoun); by myself at L'anse au Mort (Fowler); and further north about Sandwich Bay. Sea beach and sandy places. July and August. *Flora Miq.*, dry and stony places. July, August.

363. *S. vulgaris*, L. *Common Groundsel.* "Newfoundland and Labrador and Hudson Bay (Hooker, Cat. II., 263); appears

to be common everywhere in and about gardens;" sandy shore, strange to say, Flat Bay (Bell).

364. *S. sylvaticus*, L. Railway ballart, Whitbourne; abundant (R. & S.). August.

365. *S. Jacobœa*, L. *Common Ragwort.* S. John's (R. & S.) Roadsides, August.

366. *Sonchus asper*, Vill. *Spiney Sow Thistle.* New Harbour (A. C. W.), and Bay d' Espoir, Hermitage Bay (Mrs. Gallop-Macoun). August.

367. *S. arvensis*, L. *Corn or Field Sow Thistle.* "Abundant along roadsides and in fields from Newfoundland throughout the Atlantic Provinces and Quebec" (Cat. II., 283); New Harbour (A. C. W.). Gravel banks in Salmonier River, exclusively with native plants, as if indigenous (R. & S.) August.

368. *S. oleraceus*, L. *Common Sow Thistle.* Fields. Placentia (R. & S.). In Trinity Bay, at Heart's Content (Miss Southcott); and at Rawdon and New Harbour (A. C. W). "Naturalized from Newfoundland to Manitoba and B. Columbia" (Cat. II., 283). August.

369. *Solidago rugosa*, Mill. *Tall Golden Rod.* Holyrood. A smoothish form was collected in open woods near S. John's (R. & S.); at Harbour Breton (Macoun); in Bay of Islands, at Little Harbour, and Lark Harbour (Fowler); and at Benton, Bonavista Bay (Trelease) by myself. Fields and wet woods. August, September.

370. *S. arguta*, Ait. (Reeks).

371. *S. bicolor*, L. v. *concolor*, T. & G. White Bay (Bullman); in Bay of Islands, at Apsey Beach, and Shoal Point (Fowler). Two other specimens are referred to this plant by Dr. Robinson, one from Goose Arm (called *S. nemoralis*, "low canescent form" by Dr. Trelease), and the other from Coal River (said to be *S. humilis*, by Prof. Fowler). Sea cliffs and woods. August.

372. *S. Canadensis*, L. *Canadian or Common Golden Rod.* (Reeks). Trinity Bay (Cormack); S. John's (Miss Southcott);

Bay S. George (Mr. Howley-Macoun); Harbor Breton, Fortune Bay (A. C. W.), also by myself at Goose Arm; Bay of Islands (Fowler). *Lab:* L'anse au Clair (A. C. W.—Fowler). Woods August, September.

373. *S. cæsia*, L.? }
Var. *flexicaulis*, Hook. } I don't see the authority for these.

374. *S. humilis*, Pursh. (Herb. Banks, Cat. II., 213); collected by myself at Long Cove, Trinity Bay, and at Harbour Breton; in Fortune Bay (Macoun); at Gander and Exploit's Rivers, Notre Dame Bay (Drummond, E. E.—Macoun). *Lab:* (McGill Coll. Herb., Cat. II., 213—Ungava, just outside our Northern limit).

375. *S. juncea*, Ait.? S. John's (Miss Southcott) [?].

376. *S. latifolia*, L. Trinity Bay (Cormack); at Lark Harbour (Fowler). Woods. September.

377. *S. multiradiata*, Ait. Harbour Breton (A. C. W.). *Lab:* collected by myself at Mullin's Cove, Hamilton Inlet, and Independent Sandwich Bay (Macoun), and Forteau, in the Straits (Fowler). July, August.

378. *S. serotina*, Ait. var. *gigantea*, Gray. *Gigantic Golden Rod.* "Borders of thicket and low grounds. Common throughout Canada, Newfoundland, Nova Scotia, and westward to the Pacific" (Cat. II., 216); New Harbour (A. C. W.).

379. *S. squarrosa*, Muhl. *Ragged Golden Rod. Flora Miq.*, Chappean Hill. Common.

380. *S. Terræ-Novæ*, T. & G. (Pylaie, Cat. II., 215), Whitbourne. "Clearly a more corymbosely branched form of *S. uliginosa*, towards which intergradations were found near the Exploits River" (R. & S.). Bogs. August. *Flora Miq.*, Chappean Hill. Common.

381. *S. puberula*, Nutt. White Bay (Bullman). August.

382. *S. nemoralis*, Ait. White Bay (Bullman). Banks. August. (Vide *S. bicolor*, var. *concolor*, No. 371, above).

384. *S. macrophylla*, Pursh. S. John's (Miss Southcott and R. & S.); by myself at New Harbour, Trinity Bay, Harbour

Breton in Fortune Bay (Macoun); Lark Harbour (Coville), and Goose Arm (Robinson); Bay of Islands and at Benton, Bonavista Bay (Coville). *Lab:* (McGill Coll. Herb., Cat. II., 212); Ford's Harbour (Bell, Cat. III., 543); by myself at Forteau and L'anse au Clair (Fowler) in the Straits, and north of this at Battle Harbour, Deep Water Creek, and Venison Tickle (Macoun). Woods. August—October.

385. *S. uliginosa*, Nutt. *Swamp Golden Rod.* "Newfoundland, to, and beyond the Rocky Mountains in the wooded country" (Cat. II., 214); S. John's (Miss Southcott); by myself at New Harbour and Bay Bull's Arm; Trinity Bay (A. C. W.); in Bay of Islands at Shoal Point (Fowler); and near Riverhead (Robinson); and at Benton, Bonavista Bay (F.); Exploit's River, etc., (R. & S.). Wet places and woods. August.

386. *S. Virgaurea*, L. var. *alpina*, Bigel. Nipper's Harbour and Belt Cove, Notre Dame Bay (Bull—Macoun). *Lab:* Ford's Harbour and Nachvak (Bell, Cat. III., 543); Hopedale (Weiz-Packard).

387. *S. sempervirens*, L. Harbour Breton (A. C. W.).

388. *Tanacetum vulgare*, L. *Tansy.* (Reeks). Trinity Bay and Bay of Islands, here and there. *Flora Miq.*, near dwellings. August, September.

389. *Taraxacum officinale*, Weber. *Dandelion* (DUMBLEDOR). Appears to be common throughout Newfoundland about settled places, and at Battle Harbour, and some other places on the Labrador. *Flora Miq.*, common. July.

Var. alpina, Koch. *Lab:* not uncommon along the Labrador coast. Flowers usually very large (W. A. Stearns). Labrador to B. Columbia (Gray, Cat. II., 289). Rocky soil at Nachvak and Nain (Bell, III., 558); Hopedale (Weiz); and Caribou Islands (Butler-Packard).

390. *Tussilago Farfara*, L. *Coltsfoot.* S. John's (Holloway—Macoun). Lower Brook, Bay of Islands (introduced from Nova Scotia).

The *Flora Miquelonensis* notes,—"Erigeron Canadensis, L., Solidago Canadensis, L, Aster tripolium, L, Artemisia borealis, L., Carduus nutans, L., Cineraria carnosa, de la Pel., Hypocharis radicata, mentioned by Gunthier, have not been found" (by us).

LIII.—LOBELIACEÆ. *Lobelia Family.*

391. *Lobelia Dortmanna*, L. *Water Lobelia.* West of Random, Trinity Bay (Cormack), and in the same Bay, Green's Harbour and New Harbour (A. C. W.); Placentia (Lady Blake); Quidi Vidi Lake (R. & S.). Shallows, ponds and brooks. *Flora Miq.*, very common.

392. *L. Kalmii*, L. *Kalm's Lobelia.* In Bay of Islands, at Goose Arm and Middle Arm, in Bay S. George, at Seal Rock. Sandy Point (A. C. W.—Fowler). Wet quarry places and bogs, August.

LIV.—CAMPANULACEÆ. *Campanula Family.*

393. *Campanula uniflora*, L. *Lab:* Arctic regions from Labrador to Aleutian Islands (Gray. Cat. II., 287); Nachvak and Cape Chidley (Bell, Cat. III., 559); Hopedale (Weiz-Packard).

394. *Campanula rotundifolia*, L. *Rock Bellflower, Harebell.* Petty Harbour (Bell, Cat. II., 559); reported from S. John's, Bay S. George, found by myself in Trinity and Fortune Bays, White Bay and Bay of Islands. *Lab:* common (Butler and Stearns, Cat. II., 288); Battle Harbour and several places in the Straits (A. C. W.). *Flora Miq.*, abounds in the fields and in the damp portions of the island. Cliffs and rocky and sandy places. July, August.

Var. *arctica*, Lange. This is the one few-flowered forms and ranges from Canada and Labrador to the arctic regions" (Gray, Cat. III., 560); Nachvak and Cape Chidley (Bell, Cat. III., 560); Hopedale (Weiz), and L'anse Amour and Caribou Islands (Butler and Martin—Packard).

C. Scheuchzeri, Vill. Newfoundland, Labrador and Alaska (Gray, Cat. II., 287); New Harbour (A. C. W.).

Var. *heterodoxa*, Gray. Near the coast on western side of Newfoundland (Pylaie, Cat. II., 288).

These Professor Macoun (Cat. III., 560) refers to *C. rotundifolia*, L.

LV.—VACCINIACEÆ. *Huckleberry Family.*

395. *Chiogenes hispidula*, T. & G. *Creeping Snowberry.* (MAIDENHAIR, CAPILLAIRE) seems to be common and widespread in most woody parts of the country and on the Labrador (A. C. W.), so Drummond in Cat. II., 351. "Damp mossy woods, creeping over logs." *Flora Miq.*, very common. May—July.

396. *Gaylussacia dumosa.* T. & G. *Dwarf or Pale Huckleberry* (Gray, Cat. II., 289); Whitbourne (R. & S.); Little Bay, Fortune Bay. Edge of woods. August.

397. *G. resinosa*, T. & G. *Black Huckleberry.* (BLACK HURTS). (Reeks); (Cat. II., 289; rocky or sandy woodland, or swamps); by myself at New Harbour (Trinity Bay), Long Harbour (Fortune Bay), and at Little Harbour near Bay of Islands (Macoun and Fowler). Wet places. July.

398. *Oxycoccus vulgaris*, Pursh. *Common or Small Cranberry.* (MARSHBERRY). (Reeks). Very common in bogs, it would appear, throughout Newfoundland and Labrador (A. C. W.). *Lab:* Hopedale (Weiz), and Caribou Island (Butler-Packard). June—August.

399. *O. macrocarpus*, Pursh. *Large American Cranberry*, (CRANBERRY, BEARBERRY and BANKBERRY). Bogs, and especially on the margins of ponds and small lakelets in the soft mud. Newfoundland, Anticosti, Nova Scotia, etc., to Thunder Bay Macoun, Cat. II., 293); West of Random (Cormack), and New Harbour (A. C. W.) in the same neighbourhood; Cod Roy River (Bell), and Bay of Islands. Much less frequent than the last; said to be common about Lamaline and Lawn in Burin district, there called Bankberry. *Lab:* by lakelets along the coast (Abbé (Brunot: Packard). *Flora Miq.*, says of this and the last "barrens, hills, dry or damp places, almost everywhere, very common." June—August.

400. **Vaccinium Pennsylvanicum*, Lam. Common Low or Early Fruiting *Blueberry or Whortleberry.* (LOW BUSH HURTS). Very abundant on burnt tracts (R. & S.); seems to be about our most common whortleberry. I have it from White Bay, Notre Dame Bay, Bay S. George, Trinity Bay and Bay of Islands. *Flora Miq.*, very common; open woods and barrens. June to August.

Var. angustifolium, Gray. GROUND HURT. On the Labrador, TOBACCO HURT. Rocky hills, Placentia, infrequent; Salmonier (R. & S.); Trinity Bay and Bay of Islands (A. C. W.). *Lab:* (Gray, Cat. II., 290); hillsides and Caribou Island (Butler); Nain (Lundbery--Packard); Snack Cove, Sandwich Bay (A.C.W.) *Flora Miq.:* very common. June—August.

401. *V. cæspitosum*, Mx. *Dwarf or Tufty Bilberry or Blueberry.* (SUGAR HURT—Labrador), (Reeks); *Lab:* Hopedale (Weiz), and Belles Amours, and on Caribou Islands (Butler—Packard); (at Snack Cove, near Sandwich Bay, and Cape Charles (A. C. W.). Hillsides. July.

402. *V. Canadense*, Kalm. *Canadian Blueberry.* (Reeks); Bay S. George, White Bay and Bonne Bay (Bullman); Harbour Breton, Fortune Bay (A. C. W.). July.

403. *V. corymbosum*, L. *Swamp Blueberry.* (Reeks); swamps and low woods from Newfoundland to Western Ontario (Gray: Cat. II., 290); S. Paul's Bay, N. W. coast (Bullman). Wet places. July.

404. *V. Vitis-Idæa*, L. *Cowberry, Red Whortleberry* (PARTRIDGE BERRY, †REDBERRY). Very abundant from the Atlantic to the Pacific, except Southern Ontario and the prairie regions (Hook, Cat. II., 292). Appears to be abundant and widely distributed throughout Newfoundland and the Labrador.

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*The Vaccinium family (excepting V. Vitis Idæa, L.) is generally called by our people on the east coast, "hurts;" on the west coast, "blue berries."

†A dear old friend of mine, writing from the neighbourhood of Sandwich Bay, Labrador, told me, a few years ago, that she and the three girls had that fall gathered and sold 40 gallons of "bakeapples" (Rubrus Chamamorus), and 28 gallons of "red-berries."

Flora Miq., abounds in the peaty plains and also in the dry parts of the island. June—July.

405. *V. uliginosum*, L. *Mountain or Bog Blueberry* (GROUND HURT), (Cat. II., 291). In mountain bogs and exposed shores below. From Newfoundland, Labrador, etc,, thence westward to the Pacific, and northward to the Arctic Sea. Flat Bay (Bell); several places in Trinity Bay and Bay of Islands (A. C. W.); S. John's and Holyrood (R. & S.). *Lab:* at Blanc Sablon (Strait), Deep Water Creek, Seal Islands, and Hamilton Inlet (A. C. W.). Common on the coast at Nain, Ford's Harbour and Nachvak (Bell-Packard). *Flora Miq.*, very common. June—July.

406. *V. ovalifolium*, Smith. (BLUEBERRY HURT, MAZZARD). Frenchman's Cove, B. of I., in woods (A. C. W.—Robinson). *Lab:* *West S. Modest, in the Strait of Belle Isle. June.

LVI.—ERICACEÆ. *Heath Family.*

407. *Arctostaphylos Uva-Ursi*, Spreng. *Red Bearberry* (INDIAN HURT and HARDBERRY, in Hermitage Bay). *(Richardson)* rocky or sandy soil from Newfoundland to the Pacific, and north to Fort Franklin, Lat. 64° (Richardson, Cat. II., 295); Trinity Bay (Cormack and A. C. W.); Harbour Breton (Fortune Bay) and Bay de Verde, East coast, and Chimney Cove, Bay of Islands (A. C. W). Also, Sampson's Island, Notre Dame Bay, Flat Bay Brook (Bell). Sea cliffs and rocky banks. June.

408. *A. alpina*, Spreng. *Alpine* or *Black Bearberry.* Trinity Bay (Cormack); by myself at Brunet and Harbour Breton (Fortune Bay), Bay de Verde, and Swan Island, Notre Dame Bay, Great Cod Roy River (Bell). *Lab:* (McGill Coll. Herb., Cat. II., 294); Ford's Harbour and Cape Chidley (Bell: Cat III., 561): Hopedale (Weiz-Packard); by myself at Battle Harbour and L'anse au Loup. *Flora Miq*, common. Hill tops. June.

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*An intelligent resident of this place informed me that the fruit made good wine; which would imply that it was fairly plentiful, but I have only met with it once, and then in very small quantity.

409. *Andromeda Polifolia*, L. *Marsh Andromeda, Wild Rosemary.* (Reeks); common about Fortune and Trinity Bays, Chimney Cove and Little Harbour, Bay of Islands (A. C. W.); S. John's (Miss Southcott); Exploits River, and near Whitbourne (R. & S.); near Flat Bay, Bay S. George (Bell); *Lab:* Hopedale (Weiz), Caribou Island (Butler—Packard), Indian Harbour, near Battle Harbour, Square Islands, and other places (A. C. W.). *Flora Miq.*, very common. Bogs. June—August.

410. *Bryanthus taxifolius*, Gray. Mountains at Great Cod Roy River (Bell). *Lab:* (Morrison, Cat. II., 299); Nain, Nachvak, and Ford's Harbour (Bell, Cat. III., 562); Hopedale (Weiz-Packard); Battle Harbour and Seal Islands, and L'anse au Clair (A. C. W.). June—August.

411. *Chimaphila umbellata*, Nutt. *Prince's Pine* (Reeks).

412. *Cassandre calyculata*, Don. *Leatherleaf.* (Cat. II., 296). Common in Trinity and Fortune Bays and Bay of Islands (A. C. W.); near Flat Bay (Bell); Exploits River and Salmonier (R. & S.). *Lab:* (Cat. II., 296); Battle Harbour (A. C. W.); borders of lakelets and swamps along the coast (Hooker); Square Islands (B. P. Mann—Packard). *Flora Miq.*, very common. April—July.

413. *Calluna vulgaris*, Salisb. *Heath or Heather.* Near Caplin Bay, Ferryland, Renews; S. Mary's Bay and Trepassey Bay (Cormack and Lawson, Cat. II., 298) (Reeks).

414. *Cassiope hypnoides*, Don. *Moss-like Cassiope, Moss-plant.* *Lab:* (Morrison, Cat. II., 296); Nain and Cape Chidley (Bell, Cat. III., 562); Hopedale (Weiz-Packard).

415. *C. tetragona*, Don. A specimen in the museum in S. John's, named *Menziesia Polifolia*, Professor Macoun thinks may be this. *Lab:* (Kolmeister and Douglas, Cat. II., 297). Abundant along coast at Nain (Bell, Cat. III., 562); Hopedale (Weiz-Packard).

416. *Epigæa repens*, L. *Trailing Arbutus, May Flower.* (Reeks). Near Flat Bay Brook (Bell); Bonne Bay, common (Bullman); also at the Bay of Islands; Little River (Burgess);

Hermitage Bay: abundant at Rose Blanche (Revd. G. A. Field). Woods and thickets. April—June.

417. *Gaultheria procumbens*, L. *Boxberry, Tea-berry, or Partridge Berry* (MOUNTAINEER TEA). (Cat. II., 295); near Harbour Breton (A. C. W.); S. Paul's Bay, West coast (Bullman); (Reeks). *Flora Miq.*, common. June—September.

418. *Kalmia glauca*, Ait. *Pale or Swamp Laurel* (GOLD or GOULDWITHY) (Reeks). Common in peat bogs throughout the country apparently (A. C. W.). *Lab:* hillsides and swamps, Caribou (Butler-Packard); Battle Harbour, and a few other places; not so common where I have been on the Labrador as the next (A. C. W.). *Flora Miq.*, abundant; "one of the first to flower; it is also found in flower in some places even in August and September,

419. **K. angustifolia*, L. *Sheep-laurel or Lamb-hill* (Cat. II, 300). Apparently as frequent and widespread as the last (A. C. W.). *Lab:* (Cat. II., 300). West S. Modest, Chatham, and Battle Harbour *(A. C. W.). *Flora Miq.*, very common. Wet and rocky places. July—September.

420. *K. latifolium*, L. *Mountain Laurel, Calico Bush. Lab:* reported as being found in ravines and near ponds in the interior up Salmon River, and on Esquimaux Island (Stearns, Cat. II., 300).

421. *Loiseleuria procumbens*, Desv. *Alpine or Trailing Azalea* (MAY FLOWER and WHITE FLOWER in Hermitage Bay). (Morrison, Cat. II., 298); Flat Bay Brook (Bell); Pustelbrough, Hermitage Bay (Revd. H. G. Bishop); Chimney Cove, B. of I. (A. C. W.). *Lab:* (Morrison); hillsides, Caribou (Butler, Cat. II, 298); Battle Harbour and Seal Islands (A. C. W.); Hopedale (Weiz) and Ford's Harbour (Bell—Packard). *Flora Miq.*, dry places; not common. Hills. June—September.

422. *Ledum palustre*, L. (CRYSTAL TEA, Labrador) (Reeks). Newfoundland and Labrador, and through the Arctic region to

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*Called everywhere, like K. glauca, "Gouldwithy." This appears in Trinity Bay to be taken as the earlier-flowering K. glauca, in its second bloom.

Alaska and Aleutian Islands (Gray, Cat. II., 301); (Cormack). *Lab:* Seal Islands, Pack's Harbour and Snack Cove (A. C. W.); Hopedale (Weiz), and Nachvak, Ford's Harbour and Cape Chidley (Bell—Paekard) (Cat. III., 563). *Flora Miq.* says of this and the next—very common. Bogs. July.

423. *L. latifolium*, Ait. *Labrador Tea* (INDIAN or LABRADOR TEA). Peat bogs and marshes from Labrador, Newfoundland and westward to the Pacific (Cat. II., 301). Appears to be frequent in suitable habitats. *Lab:* common on hills Caribou Islands (Butler); Hopedale (Weiz-Packard). July—August.

424. *Monesis uniflora*, Gray. *One-flowered Pyrola or Wintergreen* (SWEET FLOWER, in White Bay). Very common in shady or mossy woods, from Labrador, Newfoundland, etc., westward to the Pacific and northward to Lat. 64° (Hooker, Cat. II., 306); Whitbourne, rare (R. & S.); fairly common in Trinity and Fortune Bays and Bay of Islands (A. C. W.—Macoun and Fowler); Great Cod Roy River (Bell); S. John's (Miss Southcott) and Ferryland. *Lab:* in damp and shady places (Butler); Turner's Head (Hamilton Inlet); Venison Tickle, S. Michael's, and further south at L'anse au Clair (A. C. W.); Hopedale (Weiz-Packard). *Flora Miq.*, found in groups of 12 or 15 individuals in damp peaty places, but always rare. July—August.

425. *Pyrola secunda*, L. *One-sided or Serrate Pyrola, or Wintergreen.* Rich woods throughout Canada, from Newfoundland, etc., to the Pacific, and far northward on the Mackenzie (Hooker, Cat. II., 304); S. John's (Lady Blake and R. & S.); (Reeks); White Bay, Harbour Breton and New Harbour (A.C W.). *Lab:* in the Straits of Belle Isle, at Forteau, L'anse au Mort, and Capstan Island (Eaton and Fowler). *Flora Miq.*, common. August—September.

Var. minor, Gray. Chimney Cove, Bay of Islands (A.C.W.). *Lab:* peaty bogs and mossy swamps, from Labrador to Alaska (Gray, Cat. II., 304); Hopedale (Weiz-Packard); Forteau and L'anse au Mort (A. C. W.—Fowler). Woods. August.

426. *P. minor*, L. *Smaller Pyrola.* Near Cairn Mountain, Flat Bay (Bell); (Reeks); New Harbour, in Trinity Bay (A.C.W.).

Lab: cold woods (Morrison, Cat. II., 303); Battle Harbour and neighbourhood, and in the Strait, Forteau and Blanc Sablon (A. C. W.—Fowler); Hopedale (Weiz-Packard). July, August.

427. *P. chlorantha,* Swartz. *Green-flowered or Small Pyrola.* Rather dry or sandy woods, generally under conifers, from Newfoundland, Labrador, etc., westward to the Rocky Mountains, and northward to Bear Lake (Richardson and Gray, Cat. II., 304); (Reeks); Lark Harbour and Coal River, Bay of Islands (A. C. W.—Fowler); Exploits and Gander River (Drummond, C. E.—Macoun); S. John's (R. & S.). *Lab:* (Morrison—Packard). July—August.

428. *P. rotundifolia,* L. *Round-leaved Wintergreen.* Sandy or dry woods, in swamps, and on mountain tops, from the Atlantic to the Pacific, and northward to the Arctic regions (Hooker, Cat. II., 305); Harbour Grace (Miss Trapnell—A. H. MacKay); near Cairn Mountain, Flat Bay (Bell); S. John's (Lady Blake); Sphagnum Swamp, Manuel's (R. & S.). *Lab:* in swamps, Amour (Butler). August.

Var. pumila, Hook. *Lab:* from Labrador to the Mackenzie River (Gray, Cat. II., 305). Quite common along the Labrador coast (Butler, Cat. II., 503); Battle Harbour (A. C. W.); Hopedale (Weiz-Packard). September.

Var. incarnata, D. C. *Lab:* Battle Harbour (A. C. W.). August. A doubtful specimen.

429. *Rhododendron Rhodora,* Don. *Pink Rhodora. False Honeysuckle* (BULL'S EYE, BULL'S TONGUE). Cool bogs and open peaty places, from Newfoundland, Labrador, etc., westward to the vicinity of Montreal (Maclagan, Cat. II., 302); Flat Bay, and on Cairn Mountain, white specimen (Bell); S. John's and Exploit's River, abundant (R. & S.); appears to be common and widely diffused (A. C. W.). *Lab:* hillsides, Caribou Islands (Butler-Packard). *Flora Miq.,* common. June—July.

430. *R. Lapponicum,* Wahl. *Lab:* (Morrison, Cat. II., 302); Nachvak (Bell); Hopedale (Weiz); on a hill top Belles Amours (Butler—Packard).

LVII.—MONOTROPACEÆ. *Pipewort Family.*

431. *Monotropa uniflora*, L. *Indian Pipe. Corpseplant* (GHOSTPLANT OR GHOSTFLOWER). New Harbour and B. of I., Fortune Bay (A. C. W.); near Cairn Mountain, Flat Bay (Bell); (Reeks); S. John's (Miss Southcott and R. & S. Messrs. Robinson and Schrenk remark,—" in woods near the Exploits River a small form was found, which, although agreeing as to anther and stigma with *M. uniflora*, had flowers in size just intermediate between this and *M. Hypopitys*. In drying, also, these plants have assumed an intermediate color between the black of the former species and the tawny color of the latter." Bear's Harbour, Parson's Pond, Bonne Bay (Bullman). Woods. August.

432. *Hypopitys lanuginosa*, Nutt. *Yellow or Pine Birdsnest or Pinesap* (Reeks); in woods near Exploits River (R. & S.); Great Cod Roy River (Bell); White Bay (Bullman). Woods. July, August.

LVIII.—DIAPENSIACEÆ. *Diapensia Family.*

433. *Diapensia Lapponica*, L. *Northern Diapensia* (MOSS LILY, GROUND IVORY FLOWER). Western Head, Harbour Breton and Conne in Fortune Bay, and near Rantem, Trinity Bay (A. C. W.). *Lab:* (Morrison), common on hill tops at Caribou (Butler, Cat. II., 308); Nain, Ford's Harbour and Cape Chidley (Bell, Cat. III., 564); Hopedale (Weiz—Packard). *Flora Miq.*, very common. Hills. June, July.

LIX.—PLUMBAGINACEÆ. *Leadwort Family.*

434. *Armeria vulgaris*, Willd. *Common Thrift, Sea Pink.* (Reeks); Coal River (A. C. W.—Fowler). *Lab:* Labrador, Newfoundland, and N. W. America, and in the barren country of the interior (Hooker, Cat. II., 309); Nain, Nachvak, and Cape Chidley (Bell); Hopedale (Weiz) (Cat. III., 564, and Packard). Hills and sandy plains. July.

435. *Statice Limonium*, L. Var. *Carolinianum*, Gray. *Sea Lavender, Marsh-Rosemary.* (Miss Brenton, Cat. II., 308); (Reeks); *Lab:* (Gray, Cat. II., 308).

LX.—PRIMULACEÆ. *Primrose Family.*

436. *Anagallis arvensis,* L. *Common or Scarlet Pimpernel.* Harbour Grace (McGill Coll. Herb., Cat. II., 315). *Flora Miq.*, introduced into cultivated places.

437. *A. tenella,* L. *Flora Miq.*, fields; common.

438. *Glaux maritima,* L. *Sea Milkwort, Black Saltweed.* Salt marshes along the coast of the Atlantic, from Newfoundland and Labrador to the Coast of Maine (Cat. II., 315).

439. *Lysimachia stricta,* Ait *Wood Loosestrife.* Newfoundland to the Saskatchewan (Gray, Cat. II., 314); moist ground, Whitbourne (R. & S.); Trinity Bay (Cormack), and by myself in the same Bay at Spreadeagle; Ferryland (Revd. R. Temple—Fowler); near Brigus (Miss Trapnell—MacKay). Wet places. August. *Flora Miq.*

440. *L. Nummularia,* L. *Moneywort.* Harbour Grace (McGill Coll. Herb., Cat. II., 314).

441. *Primula Mistassinica,* Mx. (Reeks; common); Middle Arm, Grand Lake, and several other places in and about Bay of Islands (A. C. W.—Fowler); Flat Bay (Bell); Batteau barrens, N. W. coast (Bullman). *Lab:* Bonne Esperance and neighbouring islands at Forteau (Butler, Cat. II, 309); Hopedale (Weiz-Packard); Battle Harbour (A. C. W.). Rocky and most exposed places. June—August.

442. *P. farinosa,* L. *Bird's Eye Primrose* (SALMON FLOWER). (Reeks; common); crevices of rocks, Port à Port (Bell); Englee, White Bay, Middle Arm, and Chimney Cove, and Coal River (A. C. W.—Fowler); Flower's Cove, in the Straits (Spence). *Lab:* crevices of rocks and exposed points along the sea, lakes or rivers (Butler); Hopedale (Weiz); Caribou Island and L'anse Amour (Butler-Packard); Sandwich Bay, Battle Harbour, Long Point (Hamilton Inlet), and L'anse au Clair (A. C. W.—Macoun and Fowler). July.

443. *P. Egaliksensis,* Hornem. *Lab:* Northern (Cat. III., 564).

444. *Samolus Valerandi,* L. Var. *Americanus,* Gray. *Water Pimpernel* (Reeks).

445. *Trientalis Americana,* Pursh. *Chickweed Wintergreen, Star Flower.* Appears to be quite common everywhere, chiefly in damp grassy woods, in Newfoundland and on the Labrador (A. C. W., Cat. II., 313, and Packard). June—August.

LXI.—OLEACEÆ. *Olive Family.*

446. *Fraxinus Americana,* L. *White Ash* (Reeks); a very rare tree; only in the country surrounding S. George's and Port a Port Bays (Prof. Howley in Geological Survey Report, p. 44).

447. *F. pubescens,* Lam. *Red or River Ash* (Reeks; common); (Howley).

448. *F. sambucifolia,* Lam. *Black or Swamp Ash.* Humber River, quite abundant, and Deer Lake, in and about Bay of Islands (Bell).

LXII.—APOCYNACEÆ. *Dog Bane Family.*

449. *Apocynum cannabinum,* L. *Indian Hemp.* Badger's Brook (Revd. I. H. Bull—Fowler). August.

450. *A. androsæmifolium,* L. Exploits River (R. & S.). Open woods. August.

LXIV.—GENTIANACEÆ. *Gentian Family.*

451. *Bartonia tenella,* Muhl. *Screwstem.* Open woods. (Gray, Cat. II., 327).

452. *Bartonia,* sp.* *(Centaurella Moseri, Steud. & Hochst.).* A plant which appears to represent, at least in part, this rare and poorly understood species, was discovered in a small bog near Holyrood (Robinson and Schrenk; for their further remarks on this plant see their "notes"). August.

453. *Gentiana crinita,* Frœl. *Blue-fringed Gentian* (Reeks).

**Bartonia iodandra*, Robinson. Botanical Gazette, 1898, July, p. 47.

454. *G. quinqueflora*, Lam. Parson's Pond, Bonne Bay (Bullman). Dry hillsides. August.

455. *G. propinqua*, Richards. *Lab:* (Gray, Cat. II., 322). On hillsides at Amour and lowlands at Bonne Esperance (Stearns —Packard). Prof. Macoun notes, however, that this is more likely to be the next.

456. *G. Amarella*, L. var. *acuta*, Hook. *Autumnal or Small-flowered Gentian.* (Reeks; common in short grass); Chimney Cove, Bay of Islands (A. C. W.—Robinson). *Lab:* (Gray, Cat. II., 322); Hopedale (Weiz), and Caribou Island (Butler—Packard); by myself in the Strait; L'anse au Clair and Forteau (Fowler). August.

457. *G. serrata*, Gunner. *Shorn or Smaller-fringed Gentian.* Wet grounds, by streams and on rocks (Gray, Cat. II., 321); Englee (Revd. R. Temple—Fowler).

458. *G. Andrewsii*, Griseb. (Reeks).

459. *G. nivalis*, L. *Small Alpine Gentian.* *Lab:* collected by the Moravian Brethren (Gray), and Hopedale (Weiz--Packard).

460. *Halenia deflexa*, Griseb. *Spursed Gentian. Felwort.* (Reeks); Conche (N. E. coast), New Harbour and Bay of Islands or Chimney Cove (A. C. W.—Macoun and Fowler). *Lab:* Forteau Bay (Miss Brodie); on hillsides at L'anse Amour, and lowlands at Bonne Espérance (Stearns); Caribou Islands (Butler —Packard); Bluff Head (Hamilton Inlet), Capstan Islands and Forteau in the Strait (A. C. W.—Fowler). Hills. August.

Var. Brentoniana, Gray. Harbour Grace (Cat. II., 326). Rocky hills, S. John's (R. & S.) August.

461. *Menyanthes trifoliata*, L. *Buck or Bog Bean.* Quite common in bogs, swamps and slow-flowing streams, from Labrador, Newfoundland, etc., to the Pacific, and northward to Sitka (Cat. II., 327) (Reeks); West of Random (Cormack), and at New Harbour in the same neighbourhood (A. C. W.); also at Hermitage Bay, Fortune Bay, Bonne Bay and Bay of Islands (A.C. W.) *Lab:* Hopedale (Weiz), and Caribou Island (Butler—Packard); Holton (A. C. W.). *Flora Miq.*, common. June.

462. *Pleurogyne rotata*, Griseb. (Cat. II., 325); Englee (A. C. W.). *Lab:* on the flat at Caribou and low lands at Bonne Espérance (Stearns—Packard); Battle Harbour, and at Sandwich Bay, and Hamilton Inlet. August.

Var? Harbour Breton (A. C. W.—Macoun).

463. *P. carinthiaca*, Griseb. Var. *pusilla*, Gray. Conche, sea beach (A. C. W.—Fowler). *Lab*: (Hooker, Cat. II., 325); Battle Harbour and neighbourhood (A. C. W.) August—September.

LXVII.—BORAGINACEÆ. *Borage Family.*

464. *Cynoglossum officinale*, L. *Common Hound's Tongue* (Reeks; rare).

465. *Echinospermum Lappula*, Lehm. (Reeks).

466. *E. Virginicum*, Lehm. (Reeks; rare).

467. *Mertensia maritima*, Don. *Sea Lungwort.* (ICE PLANT, Labrador). (Reeks). Appears to be fairly common along most parts of the coast. I have found it in all, or nearly all, the open sea beaches where I have been. *Lab:* Hopedale (Weiz), and Caribou Island (Butler); several places in the Strait, at Indian Harbour and S. Michael's. *Flora Miq.*, very common. July, August.

468. *Myosotis laxa*, Lehm. Harbour Grace (Cat. II., 340); New Harbour, Harbour Breton, Exploits, and several places in the Bay of Islands (A. C. W.—Macoun and Fowler); Manuel's (R. & S.). Gardens and waste places. July, August.

469. *M. arvensis*, Hoffm. *Field Scorpion Grass or Forget-me-not.* S. John's (R. & S.), appearing as if introduced. *Lab:* Sandwich Bay (Revd. W. Shears—Macoun). A doubtful plant. August.

470. *M. palustris*, With. *Marsh or Great Forget-me-not* Harbour Grace (Miss Trapnell—A. H. MacKay).

471. *Symphytum officinale*, L. *Common Comfrey.* Harbour Grace (McGill Coll. Herb., Cat. II., 343); S. John's (R. & S.).

LXVIII.—CONVOLVULACEÆ. *Bindweed Family.*

472. *Convolvulus sepium*, L. *Hedge or Great Bindweed.* West Bay, Cape S. George (Bell), and Stevenville, Bay S. George (A. White—A. H. MacKay); Spreadeagle in Trinity Bay, and Topsail, Conception Bay (A. C. W.) July, August.

LXIX.—SOLANACEÆ. *Potatoe Family.*

473. *Solanum Dulcamara*, L. *Bittersweet.* S. John's (R. & S.). Topsail road (Prof. Holloway—Fletcher).

LXX.—SCROPHULARIACE. *Figwort Family.*

474. *Bartsia alpina*, L. *Lab:* (Coln aster); Nachvak (Bell, Cat. II., 367 ; III., 572).

475. *Chelone glabra*, L. *Snake or Turtle Head.* West of Random, Trinity Bay (Cormack), and New Harbour in the same Bay; Frenchman's Cove, Bay of Islands (A. C. W.); Whitbourne and Exploits River (R. & S.); S. John's (Miss Trapnell--MacKay); The Goulds, near S. John's (Miss Southcott); (Cat. II., 354). Wet places. August. *Flora Miq.*

476. *Castilleia pallida*, Kunth. *Painted Cup. Lab:* Forteau (A. C. W.—Eaton). August.

Var. septentrionalis, Gray. In Bay of Islands at Chimney Cove (Fowler), and Grand Lake (Robinson) by myself; in island at north side of Deer Lake (Bell); wet places and hills. July —August. *Lab:* Hopedale (Weiz); Ford's Harbour and Nachvak (Bell—Packard).

477. *C. acuminata*, (Pursh) Spreng. Shoal Point (A. C. W. —Coville). In grassy places. July. Dr. Robinson thinks that this is the last-named plant.

478. *Euphrasia officinalis*, L. *Common Eyebright.* Appears to be common in grassy places in many districts (Cat. III., 367). *Lab:* (Cat. II., 367); Hopedale (Weiz-Packard); L'anse au Clair,

Battle Harbour and Fox Harbour (A. C. W.). *Flora Miq.*, very common. July, August.

Var. *Tartarica*, Berith. *Lab:* (Pursh), Caribou Island (Butler—Packard).

479. *E. purpurea (E. gracilis, Fries),* "new species." Sea coast at Cow Head. Much smaller in all parts; dark purple flower. (Reeks).

480. *Linaria vulgaris,* Mill. *Butter and Eggs.* Harbour Grace (Miss Trapnell). S. John's (Southcott and R. & S.); Harbour Breton (A. C. W.); La Scie, Notre Dame Bay, Revd. A. Pitman—Fowler). August.

481. *L. striata,* D. C. S. John's, on Rennie's River, but near waste heaps; doubtless a waif (R. & S.).

482. *Pedicularis palustris,* L. *Marsh Lousewort.* Moist meadows, S. John's (R. & S.). "The typical form of this does not appear to have been heretofore recorded in America. It differs from the var. *Wlassoviana,* Bunge, conspicuously in the form of the Corolla, and has also been collected in Labrador by Mr. J. A. Allen."

Var. *Wlassoviana,* Bunge (Cat. II., 369—Morrison); S. John's (Miss Southcott). *Lab:* Holton (A. C. W.) Bogs. July.

Var? S. John's (A. C. W.—Mr. Howley and Macoun).

483. *P. flammea,* L. Ford's Harbour and Cape Chidley and Nachvak (Bell); Hopedale (Weiz, Cat. III., 573, and Packard).

484. *P. hirsuta,* L. *Lab*: Ford's Harbour and Cape Chidley (Bell, Cat. III., 376).

485. *P. Lapponica,* L. *Lab:* (Kolmeister, Cat. II., 368); Nachvak (Bell) and Hopedale (Weiz—Packard).

486. *P. pedicellata,* Bunge. *Lab:* (Gray, Cat. II., 368).

487. *P. euphrasioides,* Stephen. *Lab:* (Kolmeister, Cat. II., 368); Hopedale (Weiz), and Ford's Harbour (Bell—Packard); Sandwich Bay (Revd. T. Quinton); Holton (Revd. Wm. How—Macoun).

488. *P. Grœnlandica,* Retz. *Lab:* (Morrison, Cat. II., 368); Nachvak (Bell), and Hopedale (Weiz-Packard).

489. *Rhinanthus Crista-Galli,* L. *Yellow Rattle* (SHEPHERD'S COFFIN). Appears to be very common throughout the country in grassy and wet places. *Lab:* abundant and very common in places on Bonne Espérance, and found all along the Labrador coast (Stearns, Cat. II., 371). July, August.

490. *Veronica Anagallis,* L. *Speedwell.* (Reeks). Hawk's Bay, N. W. Coast (Bullman). June, July.

491. *V. Americana,* Schwein. *American Brooklime.* Great Cod Roy River (Bell); in Bay of Islands at Riverhead (Fowler); Chimney Cove (Robinson); McIver's Cove (Trelease), collected by myself. Wet places. July, August.

492. *V. scutellata,* L. *Skull-cap Brooklime, Marsh Speedwell.* S. John's (Lady Blake); muddy bank, Whitbourne (R. & S.); at Dildo, Trinity Bay (Macoun), and at Deer Lake near Bay of Islands (A. C. W.—Fowler); (Reeks). Wet places. August.

493. *V. Buxbaumii,* Tenore. S. John's (Miss Southcott); Harbour Breton in Fortune Bay (A. C. W.).

494. *V. serpyllifolia,* L. *Thyme-leaved Speedwell.* (Reeks); New Harbour, etc., Trinity Bay, Topsail and Exploit (A. C. W.); S. John's (Lady Blake); Great Cod Roy River (Bell); Birchy Cove, Bay of Islands (A. C. W.—Fowler). *Lab*: L'anse au Clair (A. C. W.). Grassy and wet places. June and July.

495. *V. officinalis,* L. *Common Speedwell.* S. John's (Miss Southcott and R. & S.). July.

496. *V. alpina,* L. *Lab*: (Gray, Cat. II., 361); Port Burwell, Cape Chidley (Bell, Cat. III., 571); Nain (Lundbery), and Hopedale (Weiz—Packard).

497. *V. arvensis,* L. *Corn Speedwell.* New Harbour (A. C. W.).

498. *V. agrestis*, L. Rocky hills, S. John's (R. & S.); gardens, Birchy Cove, B. of I. (A. C. W.—Fowler). August.

499. *Mimulus luteus*, L. *V. sessilifolius.* Birchy Cove, B. of I. (A. C. W.—Fowler). Brooklets. August. Dr. Robinson says this is *M. moschatus*, Dougl.

500. *Scrophularia Marylandica*, (L.) Fries. *Figwort.* Meadows, B. of I. (A. C. W.—Coville). Wet places. July.

501. *Pentstemon pubescens*, Solander. *Beardstongue.* Cow Head, W. coast (Bullman). Dry soil. June.

502. *Limosella aquatica*, L. *V. tenuifolia*, Hoffm. "*Meedwort*," Sterile, and accordingly doubtful specimens collected upon precipitous cliffs of Placentia Harbour (R. & S.).

LXVI.—HYDROPHYLLACEÆ. *Waterleaf Family.*

503. *Hydrophyllum Virginicum*, L. Bonne Bay (Bullman). Wet places. July.

LXXI.—OROBANCHACEÆ. *Broomrape Family.*

504. *Aphyllon uniflorum*, Gray. *Naked or One-flowered Broomrape.* (Reeks). (Miss Brenton, Cat. II., 372); Dildo (Rev. H. Petley—Macoun); Kilbride near S. John's (Miss Trapnell—A. H. MacKay); Coal River, B. of I. (A. C. W.—Fowler). Open woods. July.

505. *Conopholis Americana*, Walb. *Squawroot.* (Reeks).

LXXII.—LENTIBULARIACEÆ. *Bladderwort Family.*

506. *Utricularia vulgaris*, L. *Common Bladderwort.* Whitbourne and Exploits River (R. & S.).

Var. *Americana*, Gray (Reeks); West of Random (Cormack); also in Trinity Bay, at New Harbour (A. C. W.). Ditches and brooks.

507. *U. minor*, L. (Reeks; rare).

508. *U. intermedia*, Hayne. Brook, Placentia (R. & S.); about New Harbour and Broad Cove, Trinity Bay, Harbour Breton, Western Cove, White Bay, Great Harbour, Hermitage Bay (A. C. W.). July—August. *Flora Miq.*, stagnant waters. Common.

509. *U. cornuta*, Mx. *Horned Bladderwort.* Sphagnous or sandy swamps from Newfoundland to Lake Superior (Gray, Cat. II., 376); (Reeks) rare; S. John's (Lady Blake); Chimney Cove and Grand Lake, and other places in Bay of Islands; New Harbour and Harbour Breton (A. C. W.); Whitbourne and Exploits River (R. & S.). *Flora Miq.*, common. July, August.

510. *Pinguicula, villosa*, L. *Lab:* (Gray, Cat. II., 376); Hopedale (Weiz-Packard).

511. *P. alpina*, L. *Lab:* Steimhauer; not elsewhere detailed in America (Gray, Cat. II., 376); Hopedale (Weiz-Packard).

512. *P. vulgaris*, L. *Common Butterwort.* (Miss Brenton, Cat. II, 376); Burin graveyard, and not uncommon about Bay of Islands (A. C. W.); Flat Bay Brook, Bay S. George (Bell). *Lab:* (Cat. II., 376); L'anse Amour Bay (Butler); Hopedale (Weiz); Nachvak (Bell—Packard); Forteau, Battle Harbour, Seal Islands, Snack Cove, Holton (A. C. W.). Wet rocks. June —August. *Flora Miq.*, common.

LXXVII.—Labiatæ. *Mint Family.*

513. *Brunella vulgaris*, L. *Seal Head.* (Reeks). Great Cod Roy River (Bell); Trinity Bay and several places about Bay of Islands and at Harbour Breton (A. C. W.), near Salmonier River; common; (R. & S.); S. John's (Miss Southcott). *Flora Miq.*, very common. July, August.

514. *Collinsonia Canadensis*, L. *Horseweed.* (Bonycastle).

515. *Calamintha clinopodium*, Benth. *Wild Basil.* Rich bottoms, Salmonier (R. & S.); Chimney Cove, B. of I. (A. C. W. —Robinson). Grassy hills. August.

516. *Galeopis Tetrahit*, L. *Dead Hemp Nettle.* S. John's (Miss Southcott and R. & S.); (Reeks); New Harbour and elsewhere in Trinity Bay (A. C. W.—Cormack); Chimney Cove, Birchy Cove and Middle Arm, Bay of Islands (A. C. W.—Fowler); Riverhead, White Bay (Bullman). Roadside and gardens. July, August.

517. *Galeopsis Ladanum*, L. *Hemp Nettle.* (Reeks); S. John's (Miss Southcott).

518. *G. versicolor*, L. S. John's (Miss Southcott).

519. *Lycopus Virginicus*, L. *Bugle weed, Virginian Horehound.* West of Random and in Trinity Bay (Cormack ; and New Harbour (A. C. W.); S. John's (Miss Southcott), and rocky banks, Rennie's River (R. & S.); Sandy Point, Bay S. George (A. C. W.—Fowler), and a few places in Bay of Islands. Wet places. August. *Flora Miq.*, common.

520. *L. sinuatus*, Ell. Salmonier River (R. & S.) Gravel beds. August.

521. *Lamium amplexicaule*, L. *Henbit Dead Nettle.* New Harbour (A. C. W.); S. John's, fields (R. & S.). August.

522. *L. purpureum*, L. *Red Dead Nettle.* S. John's (Miss Southcott); New Harbour and Harbour Breton (A. C. W.).

523. *L. maculatum*, L. New Harbour (A. C. W.) Gardens.

524. *L. incisum*, Willd. S. John's; a single specimen by roadside (R & S).

525. *Mentha viridis*, L. *Spearmint* (Reeks).

526. *M. arvensis*, L. *Cornmint.* Manuel's River, rocky banks; common along streams (R. & S.) August.

527. *M. Canadensis*, L. *Canada or Horse Mint.* New Harbour, Trinity Bay (A. C. W.), and elsewhere in the same Bay (Cormack); Flat Bay (Bell); (Reeks); Chimney Cove, and Irishtown, B. of I. (A. C. W.—Fowler). Wet places. August.

Var. glabrata, Benth. Spreadeagle, Trinity Bay (A. C. W.).

528. *Nepeta Cataria*, L. *Catnip, Catsmint.* John's Beach, B. of I. (A. C. W.). Koadside. August.

529. *N. Glechoma*, Benth. *Ground Ivy, Gill over-the-ground* (SCARLET-RUNNER). Harbour Grace (McGill Coll. Herb., Cat. II., 387); S. John's R. & S.); Topsail, old shop (Trinity Bay), and Bay de Verde (A. C. W.) *Lab*: Battle Harbour (A. C. W.). Roadside and old gardens. June—August.

530. *Scutellaria lateriflora*, L. *Maddog Scullcap*. (Reeks). Deer Lake, near Bay of Islands (A. C. W.—Fowler). River banks. August.

531. *S. galericulata*, L. *Common Skullcap*. (RED TOPS). Cat. II., 388). Trinity Bay (Cormack); Green Harbour and other places in the same Bay (A. C. W.); (Reeks); Manuel's River, rocky banks (R. & S.); Salt Water Pond, White Bay (Bullman). Sea beach. July—August.

532. *Stachys palustris*, L. *Woundwort* (Cormack); Harbour Grace (Miss Trapnell—A. H. MacKay); S. John's (R. & S., wet meadows); Sandy Point, Bay S. George, gardens (A. C. W. —Fowler. Wet ground, from Newfoundland to the Pacific (Gray, Cat. II., 390 . August.

N. B.—The *Flora Miquelonensis* says that Thymus vulgaris, L., Satureia hortense, L., Galeopsis Ladanum, L., Mentha piperita, L., Lamium amplexicaule, L., have been introduced and are found in gardens or in the neighbourhood.

LXXVIII.—PLANTAGINACEÆ. *Plantain Family.*

533. *Plantago major*, L. *Common Plantain* (RAT-TAIL.) (Reeks); Great Cod Roy River (Bell); S. John's (R. & S.); Birchy Cove, B. of I. (A. C. W.). *Lab*: Battle Harbour (A. C. W.) Roadsides. August.

534. *P. eriopoda*, Torr? Prof. Macoun thinks this may be Dr. Bell's P. Virginica.

535. *P. maritima*, L. *Seaside Plantain*. Trinity Bay (Cormack); New Harbour and other places about Trinity Bay, and at Middle Arm, and in Bay of Islands (A. C. W.); Placentia

(R. & S.). Dr. Bells says a large variety (?) was found with broad leaves and long tapering point near extremity of Flat Bay. *Lab:* (Pursh, Cat. II., 393); Nachvak (Bell, Cat. III., 575); Hopedale (Weiz); and Caribou Islands (Butler-Packard). Sea cliffs. July, August. *Flora Miq.*, very common.

536. *P. decipiens*, Barneoud. Port a Port (Bell); crevices of rocks. (P. maritima, var. juncoides, Gray). *Lab*: (Gray, Cat. II., 393).

537. *P. lanceolata*, L. *Ribwort Plantain.* (Reeks); Middle Arm and Birchy Cove, B. of I. (A. C. W.—Trelease and Robinson); S. John's (R. & S.). Fields and gardens. June—August.

538. *Littorella lacustris*, L. *Plantain Shoreweed.* Exploits River (R. & S.). Muddy banks. August.

The *Flora Miq.* remarks that *P. major*, L., and *P. lanceolata*, L., are common around houses; probably introduced.

IX.—PHENOLOGICAL OBSERVATIONS, CANADA, 1897. COMPILED BY A. H. MACKAY, LL. D., HALIFAX.

(Read 9th May, 1898).

In the following tables I have compiled the observations taken at fifteen stations throughout the Dominion from Halifax to Vancouver. Seven of these stations are in the Province of Nova Scotia. Between two and three hundred stations have had similar observations made in connection with the public schools during the year, so that there is very abundant material for the study of these phenomena in this province.* The schedule names, which are abbreviated in the tables, are those of the Public School Schedule for Nova Scotia, used also by the Botanical Club of Canada during the present year:—

PHENOLOGICAL OBSERVATIONS, CANADA, 1897.

STATIONS AND NAMES OF THE OBSERVERS.

Nova Scotia.

Berwick, Kings Co.—Miss Ida Parker.
Halifax City.—Mr. Harry Piers.
Musquodoboit Harbour, Halifax Co.—Rev. James Rosborough.
Wallace, Cumberland Co.—Miss Mary E. Charman.
New Glasgow, Pictou Co.—Miss Maria Cavanagh.
Port Hawkesbury, Inverness Co.—Mrs. G. Ormond Forsyth.
Sydney Mines, Cape Breton Co.—Miss Louise MacMillan.

Prince Edward Island.

Charlottetown.—Principal John MacSwain.

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*As this is going to press, Nova Scotian observations for 1898 have come in from between six and seven hundred stations. These will be reduced to tabular form when opportunity admits of it.

Ontario.

Niagara Falls (Queen Victoria Park).—Mr. Roderick Cameron.
Beatrice, Muskoka.—Miss Alice Hollingworth.

Manitoba.

Winnipeg.—Rev. W. A. Burman, B.D., (up to No. 57 in table).
Reston.—Mr. H. B. MacGregor, (from No. 67 to end of table).

Assiniboia.

Pheasant Forks.—Mr. Thomas Donnelly.

British Columbia.

Langley.—Mr. A. H. P. Matthew.
Vancouver.—Mr. J. K. Henry, B. A.

PHENOLOGICAL OBSERVATIONS, CANADA, 1897.

Number.	Day of the year, 1897, corresponding to the last day of each month. Jan... 31 July..212 Feb... 59 Aug..243 March 90 Sept..273 April.120 Oct...304 May..151 Nov..334 June..181 Dec...365	Berwick, N. S.	Halifax, N. S.	Musquodoboit Harbour, N. S.	Wallace, N. S.	New Glasgow, N. S.	Port Hawkesbury, N. S.	Sydney Mines, N. S.	Charlottetown, P. E. I.	Niagara Falls, O.	Beatrice, Muskoka, O.	Winnipeg, Man.	Pheasant Forks, Assa.	Langley, B. C.	Vancouver, B. C.
	(First Flowering, etc.)														
1	Alder	144	108	110	105	....	128	....	129	93	....	....	....	79	60
2	Aspen	....	....	....	115	....	133	....	125	118	129	....	....	....	....
3	Mayflower	86	98	103	113	113	113	116	114	....	....	....	....	....	....
4	Violet, blue	124	129	126	122	127	135	143	....	....	122	....	....	100	....
5	Violet, white	117	129	118	122	126	135	135	....	....	118	....	....	121	....
6	Maple, red	114	129	126	124	119	137	....	134	98	....	....	....	....	....
7	Bluets	....	....	135	....	....	....	....	....	....	....	....	....	....	....
8	Horsetail	....	....	....	....	137	161	....	....	....	131	....	....	....	....
9	Dandelion	125	134	137	137	118	137	139	142	110	126	135	....	117	89
10	A. T. Lily	....	....	....	....	131	....	....	....	111	120	....	....	79	....
11	Hepatica	....	....	....	....	130	....	....	....	91	....	....	....	....	....
12	Gold Thread	126	....	128	135	....	161	147	....	....	131	....	....	....	....
13	Strawberry	116	128	128	128	119	137	130	137	126	131	140	140	117	89
14	" fruit	159	178	....	167	158	182	177	....	159	186	....	....	....	....
15	Cherry, red	134	147	144	144	144	....	....	....	135	140	140	....	....	111
16	" " fruit	....	....	....	....	....	206	....	....	....	204	....	....	....	....
17	Blueberry	129	145	144	144	....	137	165	....	....	142	....	....	....	....
18	" fruit	201	199	....	195	....	....	....	....	....	221	....	....	....	....
19	Buttercup, tall	145	....	159	150	148	170	159	....	....	166	....	....	125	....
20	" creeping	155	....	166	167	....	171	....	....	....	....	....	....	129	....
21	Clintonia	144	....	149	....	154	....	....	....	....	....	....	....	148	....
22	Trilium, painted	....	151	153	....	154	161	....	....	....	134	....	....	....	....
23	Starflower	145	151	148	....	154	166	155	....	....	155	....	....	....	....
24	Lady's Slipper	144	154	152	....	144	172	....	....	....	150	....	....	....	....
25	Marsh Calla	....	....	....	....	....	....	....	....	....	....	....	....	....	....
26	Indian Pear	....	140	142	....	137	142	148	121	....	131	120	139	....	109

PHENOLOGICAL OBSERVATIONS, CANADA, 1897.—*Continued.*

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	(First Flowering, etc.)														
27	Indian Pear, fruit	....	205	....	....	....	201	...	....	....	...	....	....	....	....
28	Raspberry	162	.	....	174	....	....	180	....	...	172	....	....	....	....
29	" fruit	196	....	....	196	....	205	209	....	....	206	....	....	....	....
30	Blackberry	165	171	175	...	176	178	165	159	....	172	....	....	....	115
31	" fruit	213	226	....	....	256	213	....	....	....	240	....	....	....	....
32	Pale Laurel	....	....	154	....	....	172	....	....	....	150	....	....	148	....
33	Sheep Laurel	140	182	162	174	....	....	....	....	....	....	....	....	136	....
34	Pigeonberry	146	149	149	149	155	171	170	....	....	....	....	....	136	....
35	" fruit	....	....	....	....	....	....	....	....	....	....	....	....	...	....
36	Blue-eyed Grass	152	....	160	158	159	171	....	...	...	....	152	....	....	....
37	Twin-flower	155	167	...	166	....	167	....	....	....	172	....	....	156	....
38	Butter and Eggs	192	....	....	....	....	....	....	....	....	....	....	....	....	....
39	Yellow-Rattle	....	....	174	....	....	....	....	....	....	....	....	....	....	....
40	Pitcher Plant	161	.. .	174	....	162	187	....	....	....	...	....	....	....	....
41	Brunella	183	191	179	181	....	199	....	....	. ..	183	....	....	....	....
42	Epilobium	....	....	....	196	....	....	....	....	....	....	....	....	182	....
43	Wild Rose	....	....	....	189	....	....	199	....	....	...	....	....	152	....
44	Hypericum	188	197	201	...	....	224	....	....	....	....	....	....	....	....
45	Fall Dandelion	189	171	170	....	....	198	....	....	....	...	....	....	....	....
46	Cherry	....	145	....	146	146	147	....	151	127	....	....	....	....	106
47	" fruit	199	....	....	....	....	....	....	....	....	....	....	...	...	163
48	English Hawthorn	....	....	....	...	160	....	....	....	....	....	....	....	....	....
49	American Hawthorn	....	....	167	....	145	....	...	163	147	....	150	154	....	136
50	Plum	143	....	....	144	140	155	167	....	....	137	....	....	....	....
51	Apple, early	145	154	155	146	....	165	167	151	137	143	...	....	....	117
52	Apple, common	....	....	....	....	....	....	....	....	....	....	....	....	....	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1897.—*Continued.*

Number.	Day of the year, 1897, corresponding to the last day of each month. Jan.... 31, Feb.... 59, Mar... 90, April. 120, May..151, June..181, July...212, Aug...243, Sept...273, Oct....304, Nov...334, Dec.....365	Berwick, N. S.	Halifax, N. S.	Musquodoboit Harbour, N. S.	Wallace, N. S.	New Glasgow, N. S.	Port Hawkesbury, N. S.	Sydney Mines, N. S.	Charlottetown, P. E. I.	Niagara Falls, O.	Beatrice, Muskoka, O.	Winnipeg and Reston, Man.	Pheasant Forks, Assa.	Langley, B. C.	Vancouver, B. C.
	(First Flowering, etc.)														
53	Currant, red			149	137	140	152	146			140				
54	" fruit	197					203								
55	Currant, black				143						140		143		
56	" fruit														
57	Lilac	148	158	166	149	148	163	167	158	137	159	145			131
58	Potato, flower	182					186	213							
59	Timothy, flower						185								
60	Clover, white	157	170	170	174	165		181			172				
61	" red		170	166	165	160	176	177							
65a	Early leafing						138	152					130		
65b	Late leafing						154				141		146		
66	Ploughing begun	111			116		134	137					98		
67	Sowing begun	117						124		96		105	105		
68	Planting Potato	116			140		134				139		132		
69	Shearing Sheep				133		134				137		132		
70	Hay, cutting		184				194	203					188		
71	Grain-cutting		244			240		232				221	216		
72	Potato-digging				270		288						263		
	(Meteorological.)														
73a	Rivers open					95			102	96		106	97		
74	Last Snow				101	128	128							78	
75	Last Frost	102				181	180		127	140	153	159	156	117	118
76															
77	First Frost	261	275		257		241		251	259	232	241		306	
78	First Snow		322												
79	Rivers closed		338			352			357						

PHENOLOGICAL OBSERVATIONS, CANADA, 1897—*Continued.*

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	(Meteorological.)														
		....	....	....	5	....		....	....	....	68	....	....	....	76
		....	....	....	....	....	....	....	....	....	95	....	....	....	....
		....	....	....	....	....	....	....	....	113	113	....	....	....	....
		....	....	....	....	....	117	....	....	....	114	....	....	....	....
		....	....	....	....	....	126	....	....	131	129	....	....	125	126
		....	..	....	140	138	....	....	140	....	132	139	....	....	....
		....	151	....	....	142	....	....	141	....	150	141	141	149	....
		....	167	....	166	....	165	....	160	....	157	165	160	....	....
		....	169	....	169	....	....	....	169	....	174	166	165	174	...
		....	176	....	171	176	179	....	176	....	186	166	166	177	176
		....	....	....	176	....	....	....	181	....	191	181	169	....	....
		....	....	....	189	....	191	....	197	192	192	184	171	....	....
		203	....	....	213	190	....	....	....	....	194	197	....	....	....
80	Thunderstorms.....	205	218	....	218	....	203	....	....	199	200	198	...	202	....
		211	221	....	223	....	....	....	205	202	201	....	....	....	....
		213	....	....	224	....		....	...	204	202	....	....	....	....
		....	....	....	225	....	213	....	....	205	203	....	224	219	....
		....	....	....	226	....	218	....	....	206	223	225	....	220	....
		227	....	....	227	....	226	....	218	207	227	....	....	....	....
		228	228	....	....	....	229	....	221	221	236	....	....	....	236
		252	....	....	252	....	....	....	225	222	241	....	....	243	....
		....	....	....	253	....	....	....	227	228	254	....	....	248	249
		....	....	....	254	....	238	....	228	229	278	....	....	249	....
		256	....	....	256	....	....	....	229	241	289	....	....	286	....
		....	....	....	....	....	....	....	232	....	....	....	....	....	....
		....	..	..	....	....	....	....	253	...	....	....	....	....	....

PHENOLOGICAL OBSERVATIONS, CANADA, 1897,—*Continued.*

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	(Meteorological.)														
80	Thunderstorms	....	....	....	.. ....	....	....	....	258 289	....	....	....	....	.. ..	.. ..
	(Migrations, &c.)														
81	Wild Ducks	....	....	....	....	....	....	....	...	74 270	..	97	127	..	..
82	Wild Geese	81	72	..	83 340	85	79	..	86 270	91 291	132 297		87 1	21	..
83	Song Sparrow	102	90	....	....	....	95	....	99	77	....	....	....	..	..
84	Robin	67	77	....	....	87	114	110	102	74	69	....	116	..	24
85	Junco	87	96	....	....	....	....	....	106	....	....	284	....	..	..
86	Sand-piper	....	129	....	....	....	146	....	....	95	....	....	....	..	..
87	Meadow-lark	.. ..	....	....	..	....	....	....	....	96	....	95	....	..	..
88	Kingfisher	144	140	....	....	....	141	....	....	74	....	....	....	..	..
89	Yel'w-crowned Warbler	137	....	....	....	....	119	....	....	....	....	....	....	..	..
90	Yellow-bird	135	137	....	....	110	135	....	....	....	....	....	....	..	..
91	White-throated Sparrow	....	120	....	....	...	....	....	....	....	....	....	....	..	..
92	Humming-bird	139	....	....	145	....	145	....	....	132	138	....	....	..	..
93	Kingbird	138	....	....	....	....	154	....	....	....	....	139	....	..	..
94	Bobolink	138	....	....	....	....	175	....	....	....	....	144	....	..	..
95	Goldfinch	....	148	....	....	....	....	....	....	....	139	....	....	..	..
96	Redstart	....	....	....	....	....	....	....	....	....	....	....	....	..	..
97	Cedar Waxwing	....	157	....	....	...	....	....	....	....	....	....	....	..	..
98	Night Hawk	....	142	....	....	....	189	....	162	....	164	143	149	..	..
99	Piping Frogs	107	115	....	113	....	116	115	112	79	105	104	105	..	33
100	Snakes, seen	116	....	....	120	....	175	....	....	....	....	103	....	..	..

MEAN OF TWENTY PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, FOR THE FIVE YEARS, 1892 TO 1896, COMPARED WITH 1897.

Species common to the Tables of the five years.	Average Date 1892.	Average Date 1893.	Average Date 1894.	Average Date 1895.	Average Date 1896.	Five Year Mean.	Normal date of 1st flowering, etc.	Average Date 1897.
(First appearance).								
Mayflower, flower	98	108	104.7	113.55	102.70	104.79	5th April.	106.
Alder, "	102	114	116.3	103.8	107.55	108.73	9th " .	119.
Aspen, "	131	123	122.2	117.5	121.90	123.12	4th May .	128.
Maple, "	123	130	126.3	123.85	124.55	125.54	6th " .	124.8
Strawberry, "	129	133	131.6	128.55	128.50	130.13	11th " .	126.5
Dog-tooth V., "	135	136	132.2	125.	128.50	131.34	12th " .	131.
Cherry (Cult.), "	146	142	146.3	136.6	143.00	142.78	23rd " .	146.
Indian Pear, "	145	144	146.	138.35	141.65	143.	24th " .	141.8
Cherry (wild) "	150	144	147.	138.15	145.25	144.88	25th May..	142.6
Apple, "	146	146	152.1	166.65	151.10	152.37	2nd June.	155.3
Lilac, "	154	160	162.3	153.5	160.50	158.06	8th " .	157.
Hawthorn, "	163	160	160.3	148.75	160.25	158.46	8th " .	156.
Wild Goose	54	88	70.6	78.00	80.00	74.12	6th March	80.
Robin	96	94	73.2	99.30	96.14	91.73	2nd April.	91.
Song Sparrow............	99	115	79.	96.65	94.66	96.86	7th " .	95.6
Frogs piping	105	113	112.8	110.55	106.30	109.53	10th " .	113.2
Swallow	106	119	119.	125.75	117.76	117.50	18th " .	......
Kingfisher	128	137	128.7	127.50	122.00	128.64	9th May..	141.6
Humming Bird	143	159	143.0	137.25	139.30	144.31	25th "	143.
Night Hawk	150	144	158.8	148.00	154.33	151.03	1st June..	165.5

Date of publication: December 31st, 1898.

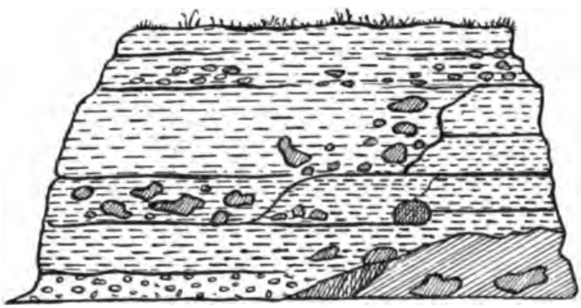

Fig. 1.

Fig. 2.

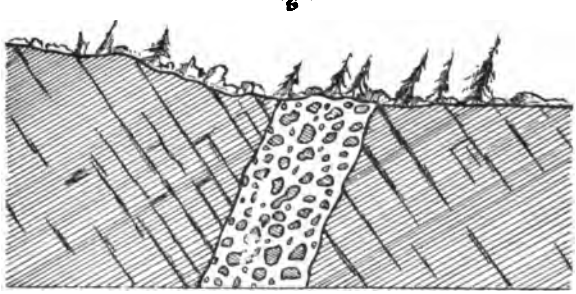

Fig. 3.

Illustrating Prof. Bailey's paper on "*Triassic Rocks of Digby Basin.*" Fig. 1, Red sandstone bluff, Digby, N. S., holding fragments of Triassic trap. Fig. 2, Bluff of red sandstone, overlaid by conglomerate, holding blocks and columns of trap, East side of Digby Gut. Fig. 3, Fissure in Triassic trap, filled with trap debris, Red Head, Grand Manan.

APPENDIX.

LIST OF MEMBERS, 1894-95.

ORDINARY MEMBERS.

	Date of Admission.	
Allison, Augustus, Halifax	Feb.	15, 1869
Anderson. James F., Dartmouth, N. S	Jan.	2, 1894
Austen, James H., Crown Lands Department, Halifax	Jan.	2, 1894
Bayer, Rufus, Halifax	March	4, 1890
Bennett, Joseph	Nov.	3, 1886
Bishop, Watson L., Dartmouth, N. S.	Jan.	6, 1890
Bliss, Donald M., Boston, U. S. A	Jan.	31, 1890
Bowman, Maynard, Public Analyst, Halifax	March	13, 1884
Brown, R. B., Yarmouth, N. S.	Jan.	10, 1891
Butler, Prof. W. R., C. E., King's College, Windsor, N. S.	Nov.	27, 1889
Campbell, Donald A., M. D., Halifax.	Jan.	31, 1890
Campbell, George Murray, M. D., Halifax	Nov.	10, 1884
Clements, E. F., Yarmouth, N, S	Jan.	10, 1891
Cowie, A. J., M. D., L. R. C. P. E., Halifax	Jan.	27, 1893
Denton, A. J	April	13, 1884
DesBrisay, A. E., Halifax	Jan.	4, 1891
DeWolfe, James R., M. D., L. R. C. S. E., Halifax	Oct.	26, 1865
Dick, Alexander, M. E., Halifax	Nov.	29, 1894
Doane, F. W. W., City Engineer, Halifax	Nov.	3, 1886
Donkin, Hiram, C. E., Point Tupper, Cape Breton	Nov.	30, 1892
Egan, Thomas J., Halifax	Jan.	6, 1890
Elliott, Miss Bertha, Halifax	March	4, 1895
Fearon, James, Principal Deaf & Dumb Institution, Halifax	May	8, 1894
Finn, William D., M. D., Halifax	Oct.	29, 1894
Faville, E. E., Director, N. S. School of Horticulture. Wolfville	Nov.	29, 1894
Forbes, John, Halifax	March	14, 1883
Foster, James G., Dartmouth, N. S	March	14, 1883
Fraser, C. F., Principal, School for the Blind, Halifax	March	31, 1890
Fraser, Rev. W. M., B. A., B. SC., Halifax	Nov.	29, 1894
Fyshe, Thomas, Halifax	Jan.	9, 1888
Gilpin, Edwin, M.A., LL.D., F.G.S., F.R.S.C.. Inspector of Mines, Halifax	April	11, 1873
Greer, T. A., M. D., Colborne, Ontario	April	7, 1893
Hall, Charles Frederick, Halifax	Dec.	31, 1894
Hare, Alfred A	Dec.	12, 1881
Harris, Herbert, Vancouver, British Columbia	Jan.	31, 1880
Hattie, William Harop, M. D., Halifax	Nov.	12, 1892
Hendry, William A., Jr., C. E., Halifax	Jan.	4, 1892
Irving, G. W. T., Halifax	Jan.	4, 1892
Jacques, Hartley S., M. D., Halifax	May	8, 1894
Johnston, H. W., C. E., Halifax	Dec.	31, 1894
Keating, E. H., C. E., City Engineer, Toronto, Ontario	April	12, 1882
Kennedy, W. T., Principal, County Academy, Halifax	Nov.	27, 1889

		Date of Admission.
Laing, Rev. Robert, Halifax	Jan.	11, 1885
Locke, Thomas J.	Jan.	4, 1892
McColl, Roderick, C. E., Halifax	Jan.	4, 1892
Macdonald, Simon D., F. G. S., Halifax	March	14, 1881
MacGregor, Prof. J. G., M.A., D.SC., F.R.SS. C. & E., Dalhousie Coll., Hfx.	Jan.	11, 1877
McInnes, Hector, LL.B., Halifax	Nov.	27, 1889
MacIntosh, Kenneth, Mabou, Cape Breton	Jan.	4, 1892
*McKay, Alexander, Supervisor of Schools, Halifax	Feb.	5, 1872
MacKay, A. H., B.A., B.SC., LL.D., F.S.SC., F.R.S.C., Superintendent of Education, Halifax	Oct.	11, 1885
MacKay, Ebenezer, B. A., Johns Hopkins University, Baltimore, U.S.A.	Nov.	27, 1889
McKerron, William, Halifax	Nov.	30, 1891
MacNab, William, Halifax	Jan.	31, 1890
Marshall, G. R., Principal, Richmond School, Halifax	April	4, 1894
Mason, F. H., F. C. S., Halifax	Dec.	31, 1894
Morrow, Arthur, M. D., Sand Coulee, Montana, U. S. A	Nov.	27, 1889
Morton, S. A., M. A., County Academy, Halifax	Jan.	27, 1893
Murphy, Martin, C. E., D. SC., Provincial Engineer, Halifax	Jan.	15, 1870
Newman, C. L., Dartmouth, N. S.	Jan.	27, 1893
O'Hearn, P., Principal, St. Patrick's Boys' School, Halifax	Jan.	16, 1890
*Parker, Hon. Daniel McN., M. D., M. L. C., Dartmouth, N. S.		1871
Pearson, B. F., Barrister, Halifax	March	31, 1890
Piers, Harry, Halifax	Nov.	2, 1888
Poole, Henry S., F. G. S., Stellarton, N. S.	Nov.	11, 1879
Read, Herbert H., M. D., L. R. C. S., Halifax	Nov.	27, 1889
Ritchie, Thomas, C. E	Jan.	2, 1894
Robb, D. W., M. E., Amherst, N. S.	March	4, 1890
Rutherford, John, M. E., Stellarton, N. S	Jan.	8, 1865
Shine, Michael, Halifax	Dec.	3, 1891
Silver, Arthur P., Halifax	Dec.	12, 1887
Silver, William C., Halifax	May	7, 1864
Smith, Capt. W. H., R. N. R., F. R. G. S., Halifax	Nov.	27, 1889
Somers, John, M. D., Halifax	Jan.	11, 1875
Spike, C. J., Halifax	May	8, 1894
Stewart, John, M. D., Halifax	Jan.	12, 1885
Tremaine, Harris S., Halifax	Jan.	2, 1894
Uniacke, Robert F., C. E	March	9, 1885
Weatherbe, Hon. Mr. Justice, Halifax	March	28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S.	Nov.	29, 1894
Willis, C. E., M. E., Halifax	Nov.	29, 1894
Wilson, Robert J., Secretary, School Board, Halifax	May	3, 1889
Yorston, W. G., C. E., Truro, N. S	Nov.	12, 1892

ASSOCIATE MEMBERS.

Caie, Robert, Yarmouth, N. S.	Jan,	31, 1890
Calkin, Principal J. B., M. A., Normal School, Truro, N. S	Jan.	6, 1890
*Cameron, A., Principal of Academy, Yarmouth, N. S	Nov.	27, 1889
Coldwell, Prof. A. E., M. A., Acadia College, Wolfville, N. S	Nov.	27, 1889
DeWolfe, Melville G., Kentville, N. S	May	2, 1895
*Dickenson, S. S., Superintendent, Commercial Cable Co., Hazelhill, Guysborough Co	March	4, 1895
Eaton, F. H., M. A., Normal School, Truro, N. S	Jan.	6, 1890

* Life Member.

Name	Date of Admission.
Faribault, E. R., C. E., Ottawa, Ontario	March 6, 1888
Fox, John J., Montreal	May 8, 1882
Hardman, John E., M. E., Halifax	March 4, 1890
Harris, Prof. C., Royal Military College, Kingston, Ontario	Nov. 13, 1881
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B.	Jan. 6, 1890
*Johns, Thomas W., Yarmouth, N. S	Nov. 27, 1889
Kennedy, Prof. Geo. T., M.A., D.SC.. F.G.S., King's College, Windsor, N. S.	Nov. 9, 1882
McKenzie, W. B., C. E., Moncton, N. B	March 31, 1882
Magee, W. H., PH. D., High School, New Glasgow, N. S.	Nov. 29, 1894
Matheson, W. G., M. E., New Glasgow, N. S	Jan. 31, 1890
Patterson, Rev. George, D. D., New Glasgow, N. S	March 12, 1878
Prest, W. H., Chester Basin, N. S	Nov. 29, 1894
*Reid, A. P., M.D. L.R.C.S., Supt. Victoria Gen. Hospital, Halifax	Jan. 31, 1890
Rosborough, Rev. James, Musquodoboit Harbour. N. S	Nov. 29, 1894
Smith, Prof. H. W., B. SC., Prov. Agricultural School, Truro, N. S.	Jan. 6, 1890
Wilson, B. C., Waverley, N. S	March 4, 1890

CORRESPONDING MEMBERS.

Ambrose, Rev. John, D. C. L., Herring Cove, N. S.	Jan. 31, 1890
Ami, Henry M., D. SC., F. G. S., Ottawa, Ontario	Jan. 2, 1892
Bailey, Prof. L. W., PH. D., F. R. S. C., University of New Brunswick, Fredericton, N. B.	Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S.	Nov. 29, 1871
Bethune, Rev. C. J. S., Port Hope, Ontario	
Dawson, Sir J. W., C. M. G., LL.D., F. R. S., Montreal	Jan. 31, 1890
Duns, Prof. John, New College, Edinburgh, Scotland	Dec. 30, 1887
Ells, R. W., LL.D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont.	Jan. 2, 1894
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario	March 3, 1891
Ganong, Prof. W. F., B.A., PH.D., Smith College, Northampton, Mass., U. S. A.	Jan. 6, 1890
Harvey, Rev. Moses, LL.D., F. R. S. C., St, John's, Newfoundland	Jan. 31, 1890
King, Major, R. A	Nov. 19, 1877
Litton, Robert T., F. G. S., Melbonrne, Australia	May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F. R. S	June 10, 1880
Marcou, Jules, Cambridge, U. S. A	Oct. 12, 1871
Matthew, G. F., M. A., F. R. S. C., St. John, N. B	Jan. 6, 1890
Maury, Rev. M., D. D., Waltham, Mass., U. S. A.	Nov. 30, 1891
Smith, Hon. Everett, Portland, Maine, U. S. A.	March 31, 1890
Spencer, Prof. J. W., PH.D., F. G. S., State Geologist, Atlanta, Ga., U.S.A.	Jan. 31, 1890
Trott, Capt., S. S. "Minia," Anglo-American Telegraph Co	Jan. 31, 1890
Waghorne, Rev. Arthur C., St. John's, Newfoundland	May 5, 1892
Weston, Thomas C., F. G. S. A., Geological Survey, Ottawa, Ontario	May 12, 1877

* Life Member.

APPENDIX.—III.

LIST OF MEMBERS, 1896-97.

ORDINARY MEMBERS.

	Date of Admission.
Allison, Augustus, Halifax	Feb. 15, 1869
Anderson, James F., Darmouth, N. S	Jan 2, 1894
Austen, James H., Crown Lands Department, Halifax	Jan. 2, 1894
Bayer, Rufus, Halifax	March 4, 1890
Bennett, Joseph	Nov. 3, 1886
Bishop, Watson L., Dartmouth, N. S.	Jan. 6, 1890
Bliss, Donald M., Boston, U. S. A	Jan. 31, 1890
Bowman, Maynard, Public Analyst, Halifax	March 13, 1884
Brown, R. B., Yarmouth, N. S	Jan. 10, 1891
Butler, Professor W. R., C. E., Royal Military College, Kingston, Ont	Nov. 27, 1889
Campbell, Donald A., M D, Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Clements, E. F., Yarmouth, N. S	Jan. 10, 1891
Cowie, A. J., M. D., L. R. C. P. E, Halifax	Jan. 27, 1893
DesBrisay, A. E., Halifax	Jan. 4, 1891
DeWolfe, James R., M D., L. R. C. S. E., Halifax	Oct. 26, 1865
Dick, Alexander, M. E., Halifax	Nov. 29, 1894
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Point Tupper, Cape Breton	Nov. 30, 1892
Egan, Thomas J., Halifax	Jan. 6, 1890
Elliott, Miss Bertha	March 4, 1895
Fearon, James, Principal, Deaf and Dumb Institntion, Halifax	May 8, 1894
Finn, William D., M. D., Halifax	Oct. 29, 1894
Faville, E. E	Nov. 29, 1894
Forbes, John, Halifax	March 14, 1883
Foster, James G., Dartmouth, N. S	March 14, 1883
Fraser, C. F., Principal, School for the Blind, Halifax	March 31, 1890
Fraser, Rev. W. M., B. A., B. SC., Halifax	Nov. 29, 1894
Fyshe, Thomas, Montreal	Jan. 9, 1888
Gilpin, Edwin, M.A., LL.D., F.R.S.C., Inspector of Mines, Halifax	April 11, 1873
Greer, T. A., M. D., Colborne, Ontario	April 7, 1893
Hall, Charles Frederick, Halifax	Dec. 31, 1894
Hare, Alfred A	Dec 12, 1881
Harris, Herbert, Vancouver, British Columbia	Jan. 31, 1880
Hattie, William Harop, M. D., Halifax	Nov. 12, 1892
Hendry, William A., Jr, C. E., Halifax	Jan. 4, 1892
Irving, G. W. T., Halifax	Jan. 4, 1892
Jacques, Hartley S., M. D., Halifax	May 8, 1894
Johnston, H. W., C. E., Halifax	Dec. 31, 1894
Keating, E. H., C. E., City Engineer, Toronto, Ontario	April 12, 1882
Kennedy, W. T., Principal, County Academy Halifax	Nov. 27, 1889

	Date of Admission.		
Laing, Rev. Robert, Halifax	Jan.	11,	1885
Locke, Thomas J	Jan.	4,	1892
McColl, Roderick, C. E., Halifax	Jan.	4,	1892
Macdonald, Simon D., F. G. S., Halifax	March	14,	1881
MacGregor, Prof. J. G., M. A., D. SC., Dalhousie College, Halifax	Jan.	11,	1877
McInnes, Hector, LL. B., Halifax	Nov.	27,	1889
MacIntosh, Kenneth, Mabou, Cape Breton	Jan.	4,	1892
*McKay, Alexander, Supervisor of Schools, Halifax	Feb.	5,	1872
MacKay, A. H., B.A., B.SC., LL.D., F.R.S.C., Superintendent of Education, Halifax	Oct.	11,	1885
MacKay, Prof. Ebenezer, PH.D., Dalhousie College, Halifax	Nov.	27,	1889
McKerron, William, Halifax	Nov.	30,	1891
MacNab, William, Halifax	Jan.	31,	1890
Marshall, G. R., Principal, Richmond School, Halifax	April	4,	1894
Mason, F. H., F. C. S., Halifax	Dec.	31,	1894
Morrow, Arthur, M. D., Sand Coulee, Montana, U. S. A	Nov.	27,	1889
Morton, S. A., M. A., County Academy, Halifax	Jan.	27,	1893
Murphy, Martin, C. E., D. SC., Provincial Engineer, Halifax	Jan.	15,	1870
Newman, C. L., Dartmouth, N. S	Jan.	27,	1893
O'Hearn, P., Principal, St. Patrick's Boys' School, Halifax	Jan.	16,	1890
*Parker, Hon. Daniel McN., M. D., M. L. C., Dartmouth, N. S			1871
Pearson, B. F., Barrister, Halifax	March	31,	1890
Peter, Rev. Bro. J., La Salle Academy, Halifax	Dec.	3,	1896
Piers, Harry, Halifax	Nov.	2,	1888
Poole, Henry S., F. G. S., Stellarton, N. S	Nov.	11,	1879
Read, Herbert H., M. D., L. R. C. S., Halifax	Nov.	27,	1889
Ritchie, Thomas, C. E	Jan.	2,	1894
Robb, D. W., M. E., Amherst, N. S	March	4,	1890
Rutherford, John, M. E., Stellarton, N. S	Jan.	8,	1865
Shine, Michael, Halifax	Dec.	3,	1891
Silver, Arthur P., Halifax	Dec.	12,	1887
Silver, William C., Halifax	May	7,	1864
Smith, Capt. W. H., R. N. R., F. R. G. S., Halifax	Nov.	27,	1889
Spike, C. J., Halifax	May	8,	1894
Stewart, John, M. B. C. M., Halifax	Jan.	12,	1885
Tremaine, Harris S., Halifax	Jan.	2,	1894
Twining, Chas., Bank of B. N. A., Halifax	Dec.	3,	1896
Uniacke, Robert F., C. E	March	9,	1885
Weatherbe, Hon. Mr. Justice, Halifax	March	28,	1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S	Nov.	29,	1894
Willis, C. E., M. E., Halifax	Nov.	29,	1894
Wilson, Robert J., Secretary School Board, Halifax	May	3,	1889
Yorston, W. G., C. E., Truro, N. S	Nov.	12,	1892

ASSOCIATE MEMBERS.

Caie, Robert, Yarmouth, N. S	Jan.	31,	1890
Calkin, Principal J. B., M. A., Normal School, Truro, N. S.	Jan.	6,	1890
*Cameron, A., Principal of Academy, Yarmouth, N. S.	Nov.	27,	1889
Coldwell, Prof. A. E., M. A., Acadia College, Wolfville, N. S	Nov.	27,	1889
DeWolfe, Melville G., Kentville, N. S	May	2,	1895
Dickenson, S. S., Superintendent Commercial Cable Co., Hazelhill, Guysborough Co., N. S.	March	4,	1895
Eaton, F. H., M. A	Jan.	6,	1890

* Life Member.

Name	*Date of Admission.*
Faribault, E. R., C. E., Ottawa, Ontario	March 6, 1888
Fox, John J., Montreal	May 8, 1882
Hardman, John E., M. E., Montreal	March 4, 1890
Harris, Prof. C., Royal Military College, Kingston, Ontario	Nov. 13, 1881
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B	Jan. 6, 1890
James, C. C., M. A., Dep. Min. of Agriculture, Toronto, Ontario	Dec. 3, 1896
*Johns, Thomas W., Yarmouth, N. S	Nov. 27, 1889
Kennedy, Prof. Geo. T., M.A., D.SC., F.G.S., King's College, Windsor, N.S.	Nov. 9, 1882
McKenzie, W. B., C. E., Moncton, N. B	March 31, 1882
McLeod, R. R., Brookfield, N. S	Dec. 3, 1897
Magee, W. H., PH. D., High School, Parrsboro, N. S	Nov. 29, 1894
Matheson, W. G., M. E., New Glasgow, N. S	Jan. 31, 1890
Prest, W. H., Chester Basin, N. S	Nov. 29, 1894
*Reid, A. P., M.D., L.R.C.S., Supt. Victoria Gen. Hospital, Halifax	Jan. 31, 1890
Rosborough, Rev. James, Musquodoboit Harbor, N. S	Nov. 29, 1894
Russell, Lee, B. S., Normal School, Truro, N. S.	Dec. 3, 1896
Smith, Prof. H. W., B. SC., Prov. Agricultural School, Truro, N. S	Jan. 6, 1890
Wilson, B. C., Waverley, N. S	March 4, 1890

CORRESPONDING MEMBERS.

Ambrose, Rev. John, D. C. L., Herring Cove, N. S	Jan. 31, 1890
Ami, Henry M., D.SC., F.G.S., Ottawa, Ontario	Jan. 2, 1892
Bailey, Prof. L. W., PH.D., LL.D., F.R.S.C., University of New Brunswick, Fredericton, N. B	Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S	Nov. 29, 1871
Bethune, Rev. C. J. S., Port Hope, Ontario	
Dawson, Sir J. W., C.M.G., LL.D., F.R.S., Montreal	Jan. 31, 1890
Dobie, W. Henry, M. D., Chester, England	Dec. 3, 1897
Duns, Prof. John, New College, Edinburgh, Scotland	Dec. 30, 1887
Ells, R. W., LL.D., F.G.S.A., F.R.S.C., Geological Survey, Ottawa, Ont	Jan. 2, 1894
Fletcher, Jas., LL.D., F.L.S., F.R.S.C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ont	March 2, 1897
Fletcher, Hugh, B.A., Geological Survey, Ottawa, Ontario	March 3, 1891
Ganong, Prof. W. F., B.A., PH.D., Smith College, Northampton, Mass., U. S. A	Jan. 6, 1890
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa	May 5, 1896
Harvey, Rev. Moses, LL.D., F.R.S.C., St. John's, Newfoundland	Jan. 31, 1890
King, Major, R. A	Nov. 19, 1877
Litton, Robert T., F. G. S., Melbourne, Australia	May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F. R. S	June 10, 1880
Marcou, Jules, Cambridge, U. S. A	Oct. 12, 1871
Matthew, G. F., M.A., F.R.S.C., St. John, N. B	Jan. 6, 1890
Maury, Rev. M., D. D., Ithaca, N. Y., U. S. A	Nov. 30, 1891
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario	Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A	March 31, 1890
Spencer, Prof. J. W., PH.D., F.G.S., Washington, D. C., U. S. A	Jan. 31, 1890
Trott, Capt., S. S. "Minia," Anglo-American Telegraph Co	Jan. 31, 1890
Waghorne, Rev. Arthur C., St. John's, Newfoundland	May 5, 1892
Weston, Thomas C., F. G. S. A., Geological Survey, Ottawa, Ontario	May 12, 1877

*Life Member.

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(Roman numerals refer to the Proceedings, Arabic numerals to the Transactions.)
